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FORECASTING OF THE ELECTROMAGNETIC AND THERMAL PROPERTIES OF SO--ETC(U)
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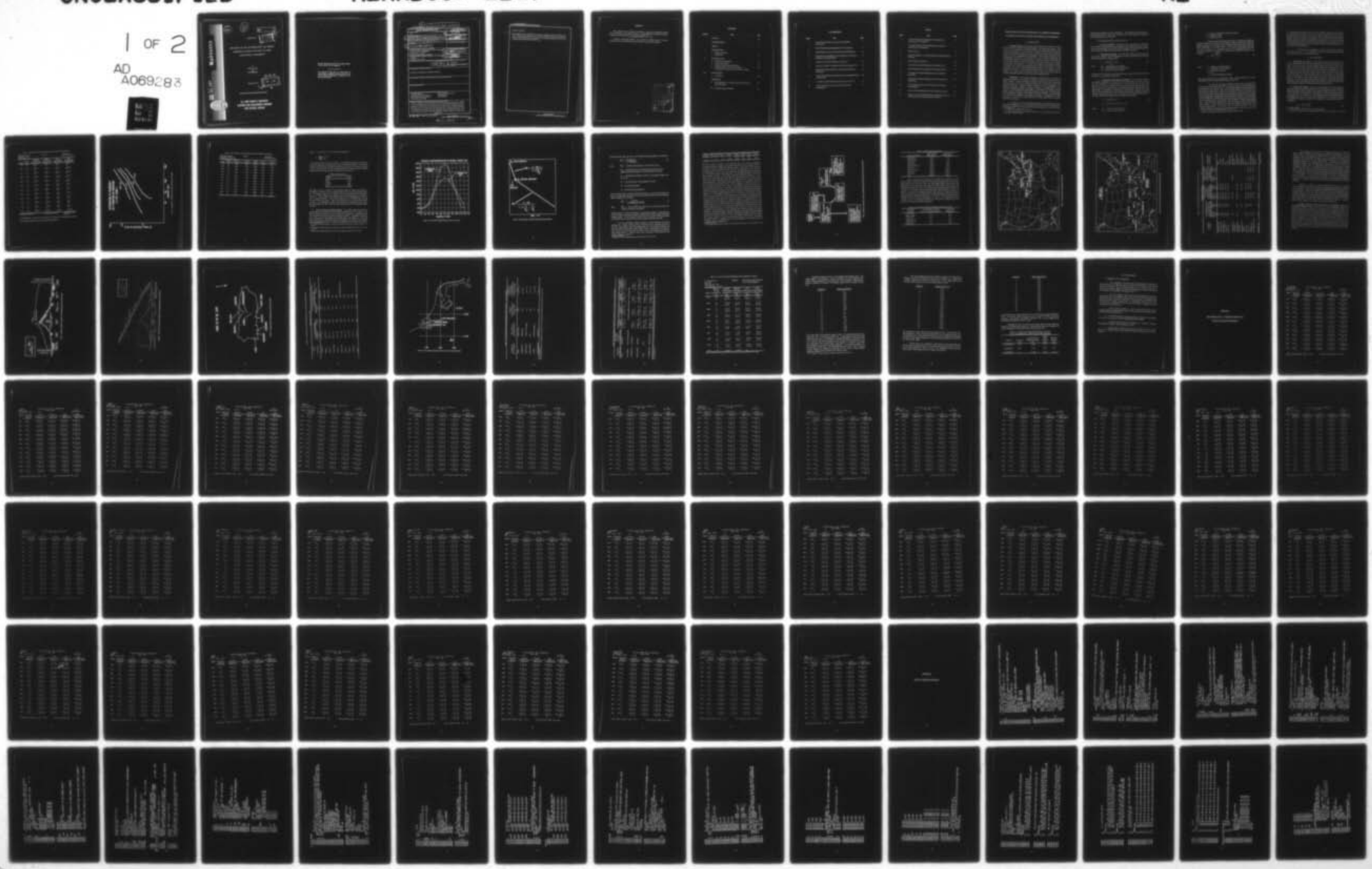

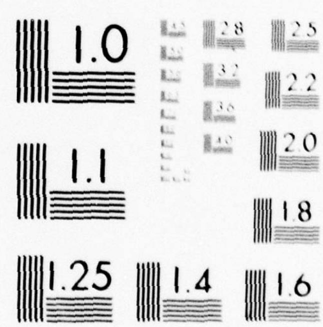

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Report 2259

FORECASTING OF THE ELECTROMAGNETIC AND THERMAL PROPERTIES OF SOILS BY THE STUDY OF THEIR CLIMATOLOGICAL ENVIRONMENT

by
Robert A. Falls
and
Louis Mittelman

September 1978

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U.S. ARMY MOBILITY EQUIPMENT
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

For a number of years, efforts have been made to accumulate data on soil – particularly, electromagnetic and thermal properties. The ultimate purpose being a better understanding of the interaction of land mine detectors and the soil. Conventional field and laboratory efforts, up to the present, have not been able to develop sufficient confidence in estimating these properties over wide geographic areas and seasons of the year. This report evaluates the efforts to develop an innovative technique utilizing the available labo- CONT

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ratory/field data with a climatological concept that estimates seasonal, soil-moisture behavior. Once the yearly variation of the moisture is established for an area, all other soil properties related to moisture can be predicted. Currently, the probability of success using this predictive technique is approaching 0.75.

PREFACE

This evaluation was accomplished by Robert A. Falls and Louis Mittelman, Mine Detection Division, Countermine Laboratory, USAMERADCOM, Fort Belvoir, Virginia, during the period September 1974 through September 1977.

Computer programing guidance was provided by William Loudin, Electrical Engineer, formerly of the Mine Detection Division, Countermine Laboratory.

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FORECASTING OF THE ELECTROMAGNETIC AND THERMAL PROPERTIES OF SOILS BY THE STUDY OF THEIR CLIMATOLOGICAL ENVIRONMENT

I. INTRODUCTION

1. **Purpose and Scope.** The purpose of this research was to determine a method that could be used in forecasting electromagnetic and thermal soil properties. Electronic detector performance on buried land mines and antipersonnel mines is influenced by soil properties. It was imperative to determine data for research design and field use, which soil properties were critical, and how they could accurately be determined for any given geographical area worldwide. Past research has identified that electromagnetic attenuation and permittivity as well as thermal conductivity and capacity most influence detector performance. This report concerns the investigation of a method to identify a forecasting technique that can effectively be used in determining critical soil properties. A variation of the Budyko water-balance technique was analyzed as a tool for predicting soil moisture which in turn would be a means to provide values of the critical E-M properties required. The ultimate use of the information provided by the technique investigated will be to influence detector designs and to provide the Army field user with a manual which will indicate the detector capabilities presently in hand in that specific geographic area.

2. **Background.** In the past, information concerning values of various soil parameters necessary to the subsurface of voids and objects was so scattered as to be almost unusable. Values of microwave attenuation of the three basic, soil-textural types (sand, silt, and clay) were widely spaced because of the small number of soil moisture levels used.[1] During the 1960's, excellent work was accomplished at the Waterways Experiment Station, Vicksburg, Mississippi, in determining the radar responses to laboratory-prepared soil samples.[2] Large numbers of laboratory samples having a variety of moisture contents and densities were prepared. Standard, pulsed radars operating at frequencies of 297 MHz, 5870 MHz, 9375 MHz, and 34,534 MHz were directed at the samples at several angles of incidence. The purpose was to relate the moisture content of the soil samples with the radar returns and the electrical properties they provided.

The approach of the Countermine Laboratory in determining electromagnetic (E-M) properties was to use Constant Wave (CW) between the frequencies of 100 MHz and 4000 MHz because several of the mine detectors in use then and now

[1] A. Von Hippel, *Dielectric Materials*, MIT, 1954, p. 314.

[2] J. R. Lundien, *Terrain Analysis by Electromagnetic Means*, Report 2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, Sep 66.

have discrete frequencies in their transmitters. The Laboratory E-M analysis was initiated during the late 1960's; and, until about 1973, the analysis was performed in the laboratory and not in the field.

The following laboratory methods were tried:

a. **Gunzton Technique.** The intrinsic loss of a soil packed in a coaxial line can be found by measuring the input impedance of the network for a series of positions of a movable short circuit at the output terminals. This is a laboratory method and reveals the attenuation only at frequencies of 100 MHz and above.

b. **Power-Ratio Technique.** This method is based on the fact that the one-way loss through a network containing a soil sample, matched both at the input and output, is given by a simple equation:

$$L_i = 10 \log \frac{P_{out}}{P_{in}} \text{ (dB)} \tag{1}$$

where P_{in} = Input power to the network.
P_{out} = Power delivered to a matched load.
L_i = Intrinsic loss of the network.

The Power-Ratio Technique is faster and less prone to human error than the Gunzton Technique. It is a laboratory method only.

c. **Transmission-Line Technique (Kirkscether).** The soil sample is packed in a suitable transmission (coaxial) line. An adequate length of the soil is selected (15 to 30 centimeters). The input impedance of the line with the soil is measured with the far end of the sample line short circuited and then open circuited. The method can be used to determine the conductivity, dielectric constant, attenuation, and velocity of propagation. Kirkscether's transmission-line method was finally selected, and it produced most of the laboratory data at the Countermine Laboratory during the late 1960's and early 1970's. The values of attenuation (α) and permittivity (β) can be ascertained by employing the following general equations:

$$\alpha = \tfrac{1}{4}L \ln[f(Z_{sc}, Z_{oc})] \tag{2}$$

$$\beta = \frac{1}{L} \tan^{-1} g(Z_{sc}, Z_{oc}) + Z_{oc} + \pi\eta. \tag{3}$$

where Z_{sc} = Short-circuited impedance.
Z_{oc} = Open-circuited impedance.

η = Number of wavelengths within the material.
L = Length of sample.
g = Complex function.

A variation of the transmission-line technique , developed by Southwest Research Institute, San Antonio, Texas, enabled its basic principle to be utilized to develop an in-situ kit to measure the soil attenuation and the permittivity from 300 MHz to 4000 MHz. In the field version, a coaxial probe long enough to penetrate the soil to a depth of 2.5 centimeters was used. The electromagnetic loss of the soil within the probe is a function of the open-circuited impedance as defined in the equation:

$$z_o = \frac{j\omega\mu}{\gamma} \frac{\ln\left(\frac{b}{a}\right)}{2\pi} \tag{4}$$

where b = Diameter of center conductor.
a = Diameter of outer conductor.
ω = Frequency in radians.
j = $\sqrt{-1}$.
γ = Complex propagation constant.

This in-situ method was used successfully in West Germany during 1973,[3] in the Netherlands in 1974, and again in West Germany in late 1975.

The field and laboratory techniques suffer from two deficiencies: (1) a slowness in accumulating data, and (2) the recompaction and redistribution of the natural density and texture of the soil. The methods employed always disturbed the soil medium in some fashion. Also, the E-M values obtained in the field with the in-situ kit were valid for only a week or two barring rains. Because of the short data life of the field E-M values (attenuation and permittivity) and the slowness in accumulating these properties, the philosophy of the program was changed. A new philosophy was accomplished by combining the expertise of past and present laboratory investigations of electromagnetic soil properties with published, worldwide climatological data.[4] These two areas of information were made available to a CDC 6600 computer which produced a vibrant program many times more flexible and responsive to the needs of the scientist and engineer than the previous methods. The result

[3] Robert A. Falls, *The Electromagnetic and Physical Properties of Soils in Analogous Locations in the Federal Republic of Germany and USA*, MERDC Report No. 2103, June 1974.

[4] Frederick L. Wernstedt, *World Climatic Data*, Climatic Data Press, Lemont, PA, 1972.

is a computerized, monthly forecast of the soil moisture, attenuation, permittivity, and several thermal properties at any one or group of the 10,767 climatic stations throughout the world. Table 1 is an example from one climatic station. The computer method also has the potential of indicating areas and seasons most beneficial for infrared detection of surface manifestations of buried mines. At least, it is capable of determining reasonable values of thermal conductivity, capacity, diffusivity, resistivity, and thermal property. Table 2 lists the forecasted, thermal values of a soil in Oudenbosch, the Netherlands.

At this time, the probability of correct, long-distance forecasting is between 0.65 and 0.75. The probability of higher correlations will depend upon the textural resolution of any particular soil map.

II. INVESTIGATION

3. Measurement and History. The primary variable which determines the level of electromagnetic losses and permittivity within any soil is the amount of water present. Once a soil type is identified, published data from a good soil physics textbook[5] will reveal an upper and lower limit to the amount of water it can retain. Therefore, once the yearly variation of the soil moisture is established for an area, all other soil properties related to moisture can be predicted. This statement defines the uniqueness of the Terrain Forecast Program. Past laboratory work provided data on the range of the electromagnetic losses to be expected for each soil texture type (i.e., sand, loam, or clay) from conditions of dryness to conditions of complete saturation. An example of this variation is shown in Figure 1. Utilizing the laboratory information with a climatological concept that estimates seasonal, soil-moisture behavior essentially outlines the Worldwide Terrain Forecasting method.

4. Theory and Analysis. The rate at which moisture is extracted from an open-water surface (Potential Evaporation) and a vegetated ground surface (Potential Evapotranspiration) depends chiefly on the average monthly temperature. The best known and widely used method for determining the potential evapotranspiration was devised by C. W. Thornwaite.[6] He developed empirical relationships between evapotranspiration (E_T) and the monthly temperature (T) in degrees centigrade. A variation of Thornwaite's equation for calculating the potential evaporation (E_o) is as follows:

$$E_o = 18.936 \frac{10\,T^a}{I} \tag{5}$$

5 L. D. Baver, *Soil Physics*, John Wiley & Sons, 3rd ed., 1956, pp. 285-289.

6 C. W. Thornwaite, "An Approach Toward a Rational Classification of Climate," *Geographic Rev.*, Vol 38, pp. 55-94.

Table 1. Computer Printout Forecasting the E-M Parameters for Oudenbosch, the Netherlands

Oudenbosch Loamy Clay
Field Capacity = 28.2%
Critical Moisture = 21.3%

Bare Soil

Field Capacity
530.-540. mm/1500 mm

Month	Moisture % by Wt.	300 MHz ATTN/EPSILON Standard Dev (dB)	500 MHz ATTN/EPSILON Standard Dev (dB)	1GHz ATTN/EPSILON Standard Dev (dB)	2GHz ATTN/EPSILON Standard Dev (dB)
JAN	18.2	38./15.0	50./13.6	84./12.7	124./11.4
	.1	.1/.1	.1/.1	.4/.1	.6/.1
FEB	19.0	39./15.7	51./14.3	87./13.3	128./11.9
	.1	.1/.1	.1/.1	.4/.1	.6/.1
MAR	19.1	39./15.7	51./14.3	87./13.4	129./11.9
	.1	.2/.1	.1/.1	.4/.1	.6/.1
APR	18.0	37./14.8	49./13.5	83./12.6	123./11.2
	.1	.2/.1	.1/.1	.4/.1	.6/.1
MAY	15.9	35./13.0	47./11.9	75./11.1	111./9.9
	.1	.2/.1	.1/.1	.4/.1	.6/.1
JUN	13.5	32./11.0	44./10.1	67./9.4	99./8.5
	.1	.1/.1	.1/.1	.4/.1	.6/.1
JUL	12.3	30./10.0	43./9.2	62./8.5	92./7.7
	.1	.1/.1	.1/.1	.4/.1	.5/.1
AUG	12.1	30./9.8	42./9.0	61./8.4	91./7.6
	.1	.1/.1	.1/.1	.3/.1	.5/.1
SEP	12.4	30./10.0	43./9.3	62./8.6	93./7.8
	.1	.1/.1	.1/.1	.3/.1	.5/.1
OCT	13.5	31./11.0	44./10.1	66./9.4	99./8.5
	.1	.1/.1	.1/.1	.3/.1	.5/.1
NOV	15.1	34./12.3	46./11.3	72./10.5	107./9.5
	.1	.1/.1	.1/.1	.4/.1	.5/.1
DEC	16.5	36./13.6	48./12.4	78./11.6	115./10.4
	.1	.1/.1	.1/.1	.4/.1	.5/.1

Total Rain 29.1 Inches/Year

Pan Evap. 30.9 Inches/Year

Critical Moisture (mm)
400.-405.

Attenuation/EPSILON: Attenuation is E-M loss in dB per meter. EPSILON is the calculated dielectric constant.

Note: Second row of numbers for each month represents standard deviation.

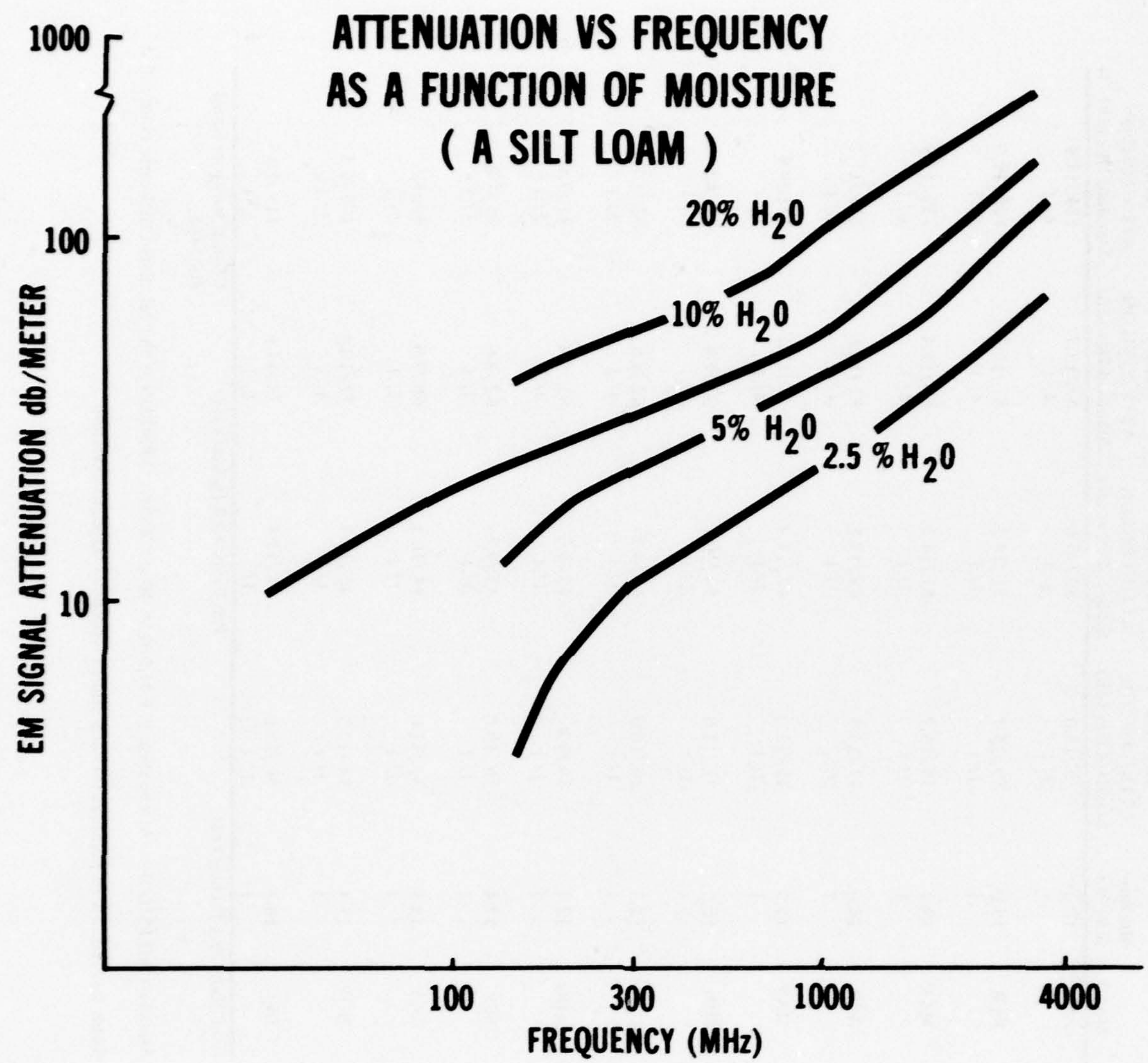

Figure 1. Attenuation vs frequency as a function of moisture (a silt loam).

Table 2. Computer Printout of the Thermal Properties of Soil for Oudenbosch, the Netherlands

Oudenbosch Loamy Clay
Field Capacity = 28.2% by wt.
Critical Moisture = 21.3% by wt.

Bare Soil

Field Capacity
530-540 mm/1500 mm

Month	Moisture % by Wt.	TCOND (cal cm^{-1} sec^{-1} $°C^{-1}$)	TCAP (cal cm^{-3} $°C^{-1}$)	TDIFF (cm^2 sec^{-1})	TP (ly $°C^{-1}$ $sec^{-1/2}$)	TR (cal^{-1} cm^2 °C)
JAN	18.2	.0028	.4046	.00699	.0338	29.55
FEB	19.2	.0029	.4145	.00698	.0346	28.86
MAR	19.1	.0029	.4152	.00698	.0347	28.82
APR	18.0	.0028	.4021	.00699	.0336	29.73
MAY	15.9	.0026	.3781	.00698	.0316	31.64
JUN	13.5	.0024	.3510	.00689	.0291	34.32
JUL	12.3	.0023	.3370	.00677	.0278	36.01
AUG	12.1	.0023	.3342	.00676	.0275	36.38
SEP	12.4	.0023	.3376	.00679	.0278	35.94
OCT	13.5	.0024	.3507	.00688	.0291	34.36
NOV	15.1	.0026	.3693	.00698	.0308	32.44
DEC	16.5	.0027	.3858	.00699	.0323	30.98

where $a = (0.675\, I^3 - 77\, I^2 + 17{,}920\, I + 492390)\, 10^{-6}$

$$I = \sum_{1}^{12} \left(\frac{T}{5}\right)^{1.514}$$

"I" is called the heat index of a location. It was decided early in the research to develop an approach to calculate the E_T after the method of Penman.[7] His research indicated that the ratio of freshly wetted bare soil to that of an open-water surface (E_T/E_o) was about 0.90. He also determined that the E_T from turf with a plentiful supply of water was a function of the season of the year (Table 3).

Table 3. Ratios of E_T/E_o

Season	E_T/E_o
Winter	0.60
Spring	0.70
Summer	0.80
Fall	0.70

The ratios of E_T/E_o in Table 3 were developed under the climate and latitude of SE England and are based on an unlimited supply of water to the roots of the vegetation. In humid regions near the equator, "this ratio approaches 0.70 throughout the year."[8] Desert regions have understandably lower evapotranspiration ratios because of sparse vegetation. These ratios remain near 0.55 throughout the year and are less sensitive to latitudes. A plot of the potential E_T for two locations is shown in Figure 2. This potential E_T value is always less than the potential E_o value and is also the starting point upon which all other calculations for the forecasting technique are based.

5. Terrain Forecast Computer Program. The method which has shown the most promise in forecasting the seasonal moisture behavior of the 1.5 meters of soil depth in vegetated areas (0.10 to 0.20 meter in bare ground) is a simplified version of the Budyko water-balance method published by Sellers.[9] According to this technique, there are two, and possibly three, drying stages in soil (Figure 3). In the first stage, when there is a considerable amount of moisture in the soil, the rate of drying of the soil depends primarily on external meteorological factors (rainfall, evaporation).

[7] H. L. Penman, "Natural Evaporation from Open Water, Bare Soil, and Grass," *Proc. Roy. Soc. London, A 193*: 120-145.

[8] H. L. Penman, "Estimating Evaporation," *Transactions of American Geophysical Union*, Vol. 37, No. 1, p. 45, Feb 1956.

[9] William D. Sellers, *Physical Climatology*, The University of Chicago Press, Chicago, IL, p. 175, 1974.

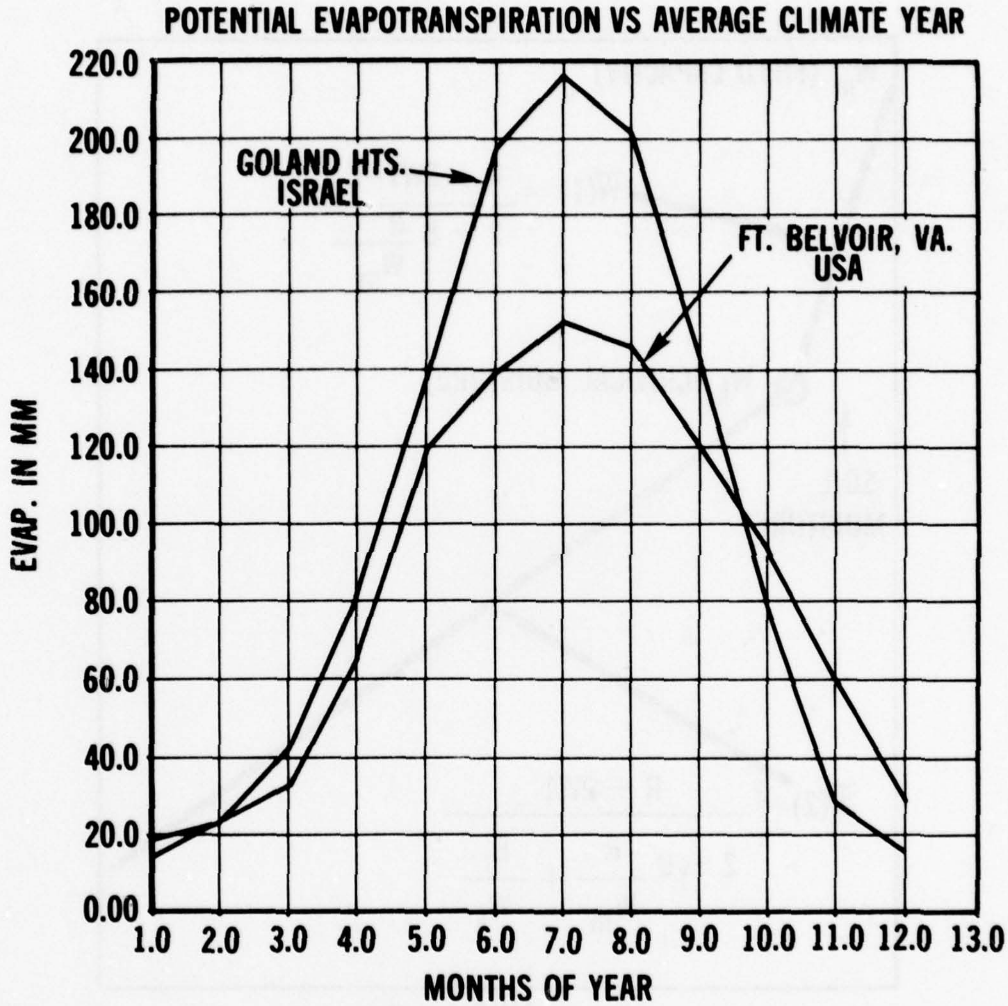

Figure 2. Plot of potential evaportranspiration for two locations.

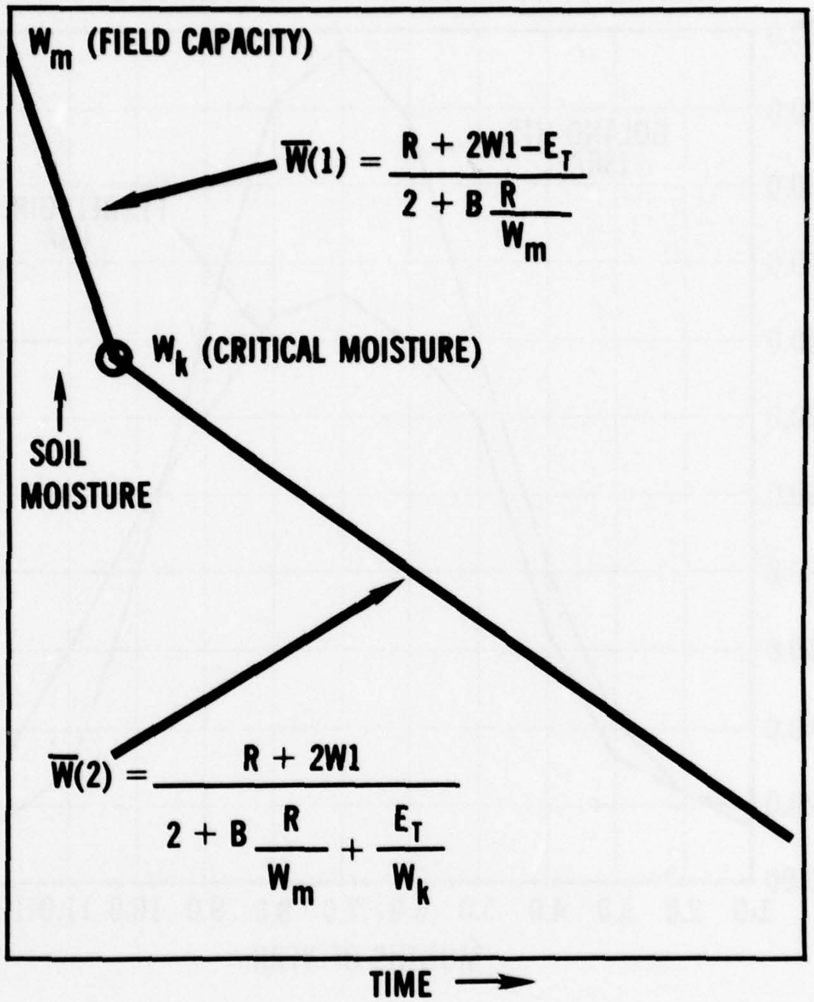

Figure 3. Drying stages in a soil with associated empirical equations.

During this first stage, the rate of soil drying proceeds according to the formula:

$$\overline{W}(1) = \frac{R + 2W_1 - E_T}{2 + B(R/W_{max})} \tag{6}$$

where $\overline{W}(1)$ = Calculated soil moisture at the end of the month.

W_{max} = Maximum amount of soil moisture that a soil can hold against gravity (field capacity). It is directly related to texture.

B = Empirically determined constant of proportion ranging from 0.2 to 0.8.

W_1 = The soil moisture at the beginning of a month.

R = Total monthly rainfall.

E_T = Potential evapotranspiration.

If the soil dries below a critical moisture level (W_k), as it may in the summer, it is then in a second stage where the rate of drying rapidly decreases and the soil moisture W(2) is calculated by the formula:

$$\overline{W}(2) = \frac{R + 2W_1}{2 + B(R/W_{max}) + E_T/W_k} \tag{7}$$

where $\overline{W}(2)$ = The calculated soil moisture at the end of the month if the moisture is below the critical level.

Formulas (6) and (7) form the nucleus of a water-balance method. A slight variation of the technique as described by Sellers correlates quite well with field confirmation (roughly within ± 7% of forecasted moisture values.) Excellent detailed discussion on the method can be found in several recent physical climatology textbooks.

The three parameters needed to obtain an accurate forecast of the terrain anywhere are: average monthly rainfall, temperature, and a reasonable estimate of the type of soil present. Part of this information for 10,767 stations throughout the world was found in Wernstedt's *World Climatic Data.* [10] Although his data is unavoidably uneven in duration and length of climatic records and geographical distribution, every political unit, i.e., country, colony, state, or province, is represented as in the sample compilation (Table 4).

[10] Frederick L. Wernstedt, *World Climatic Data*, Climatic Data Press, Lemont, PA, 1972.

Table 4. Sample Compilation of Average Temperature and Rainfall from Wernstedt

Station	Yr.	Elev.	Lat.	Long.	JAN	FEB	NOV	DEC
					53.4°F	57.7	61.8°F	55.1°F
Yuma	89	199	32.4	114.56W	0.39″	0.39″	0.21″	0.45″

Such data as shown in Table 4 was an important find. It was the first compilation of average, long-term, monthly and annual temperature and precipitation data for a network of nearly 19,000 world climatic stations. This data is vitally necessary for input to terrain forecasting research. However, because the data was in the form of a printed list, its use as a source of rapid input of climatological data was limited. It was not until a magnetic tape equivalent of the climatological data was found that great potential was given to the whole terrain-forecasting idea (Figure 4). At the present time, soil-texture data, the third and last necessary piece of input data to create the terrain forecasting analysis, is not compiled in such a usable form as the climatological data. The greatest textural compilation so far available was developed by the US Soil Conservation Service.[11] This compilation is limited, however, to the continental US, Puerto Rico, and the Virgin Islands. The exact location of the various soil-textural types is not clear-cut in the US Soil Conservation compilation. Therefore, at the present time, most textural information is derived from soil textural maps. Soil texture is equatable to the amount of water it can hold (field capacity). Therefore, a soils-textural classification can be reduced to field capacity in millimeters of water per unit depth of ground (in this case, 1500 mm), and critical moisture can be expressed in the same units. These, then, are the input data supplied to the computer along with rainfall and temperature (Table 5). Summarizing, then, the computerized research program is capable of reading the location and country code number typed in at the input terminal. The computer then retrieves from the climatological magnetic tape the correct monthly temperature and rainfall for the location. The researcher finally has to decide what major soil types are present in the area of interest. This information can be obtained from soil-texture maps of the various countries. The three parameters (rainfall, temperature, and soil texture) are supplied to the terrian computer program. Here, the forecasted soil-moisture content is calculated for each month of the year. Once this monthly moisture value is obtained, the program searches a common data block subroutine in which all the accumulated laboratory, field, and published data on the electromagnetic and thermal properties of soils is stored (See Appendix B).

[11] Soil Conservation Service, USDA, "Soil Series of the United States, Puerto Rico, and the Virgin Islands," Aug 72.

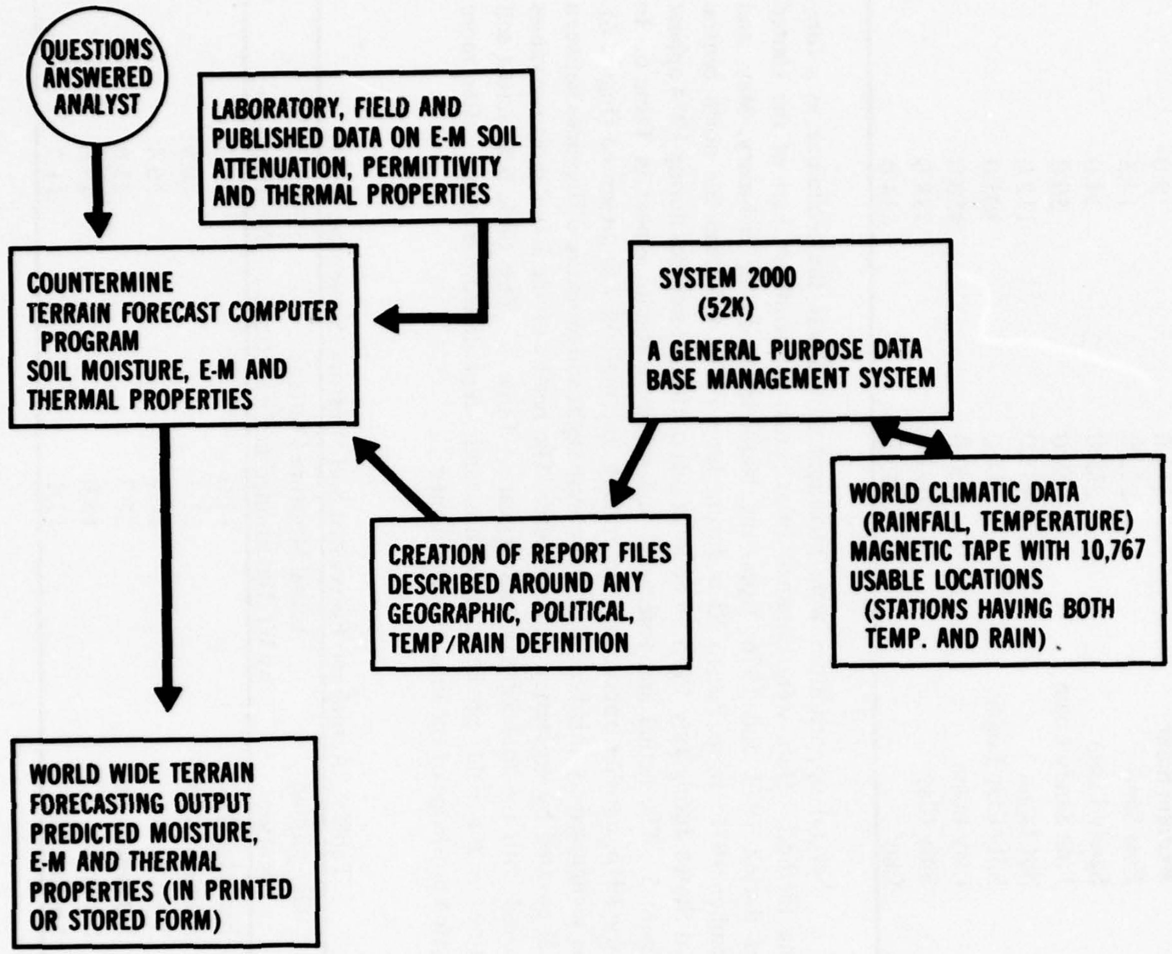

Figure 4. Elements of the soils moisture, electromagnetic and thermal properties forecasting method.

Table 5. Soils Textural Classification

Type Soil (Texture)	Field Capacity MM/1500 mm	Critical Point MM/1500 mm
Coarse Sand	78.0	3.5
Medium Sand	161.0	9.0
Fine Sand	222.0	14.5
Sandy Loam	289.0	24.0
Fine Sandy Loam	359.0	50.0
Silt Loam	433.0	112.0
Silty Clay Loam	514.0	405.0
Clay Loam	600.0	450.0
Silty Clay	691.0	538.0
Clay	813.0	634.0

Several opportunities were presented to evaluate the technique as a forecasting method. Data were obtained from across the southern part of the United States during 1974 and 1976; from the Netherlands during February, May, and September 1976; from Puerto Rico during June 1976; and from the north central United States during July 1976. The locations of the soil samples during 1974 appear in Figure 5. The actual and forecasted soil moisture results appear in Table 6. In January 1976, another opportunity to evaluate the method was presented (Figure 6). It was recognized by this time that there were slight soil-moisture differences between ground covered by vegetation and bare soil. The results of the actual moisture values compared with the forecasted values appear in Table 7. This table lists actual soil moisture in the field, predicted moisture, and "repredicted" moisture after more accurate knowledge of the locations was gained.

Table 6. Actual and Forecasted Soil Moisture (September 1974)

Geographic Location	Actual Moisture Content by Wt. Determined in Field (%)	Forecasted Moisture (%)
Nowata, Ok.	17.0	17.3
Ironton, Ohio	21.3	20.9
Vienna, Ill.	17.9	16.4
Lafayette, Ind.	27.7	25.6
Seabrook, N.J.	18.0	19.6
Lorton, Va.	11.1	11.7

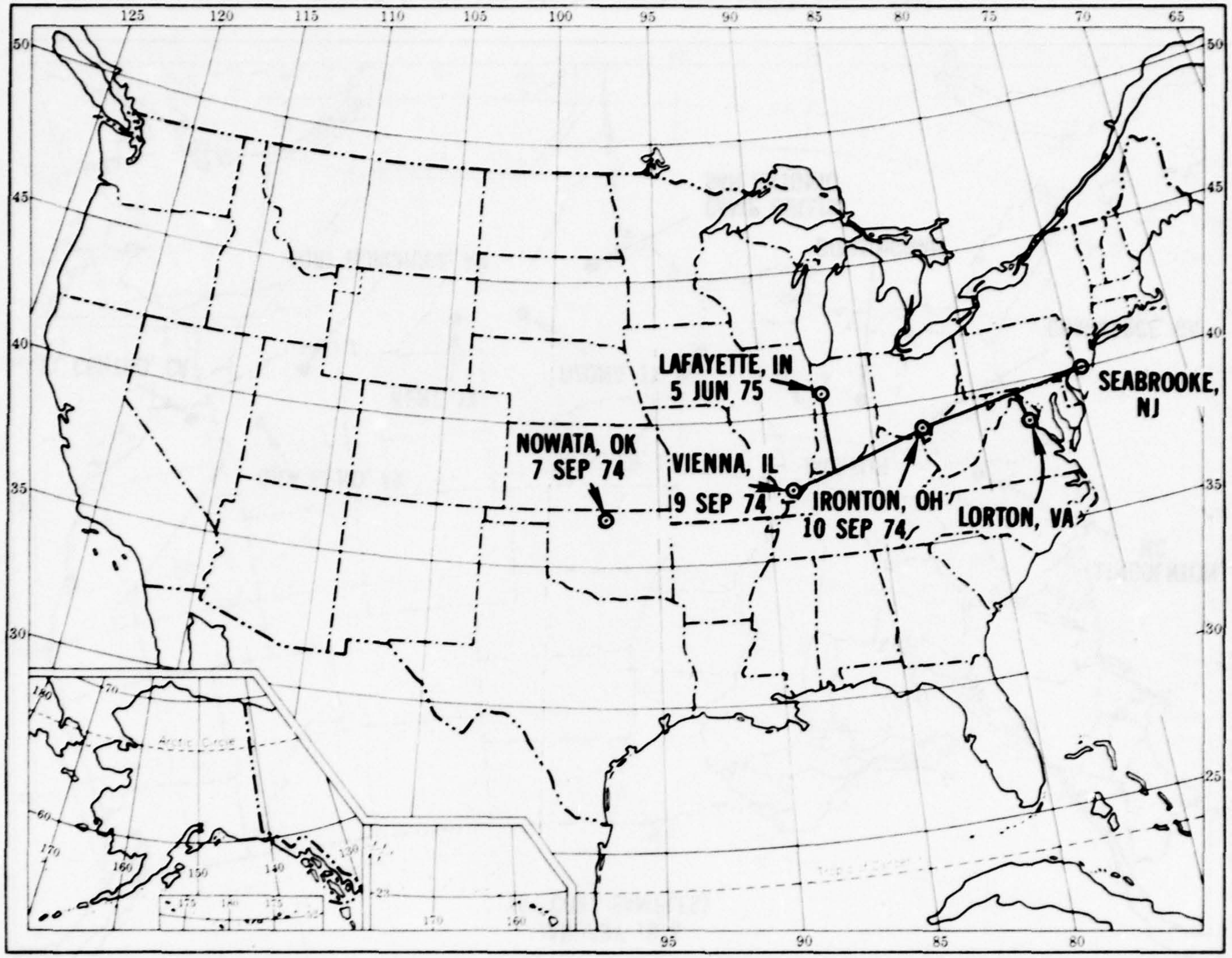

Figure 5. Locations at which soil samples were collected.

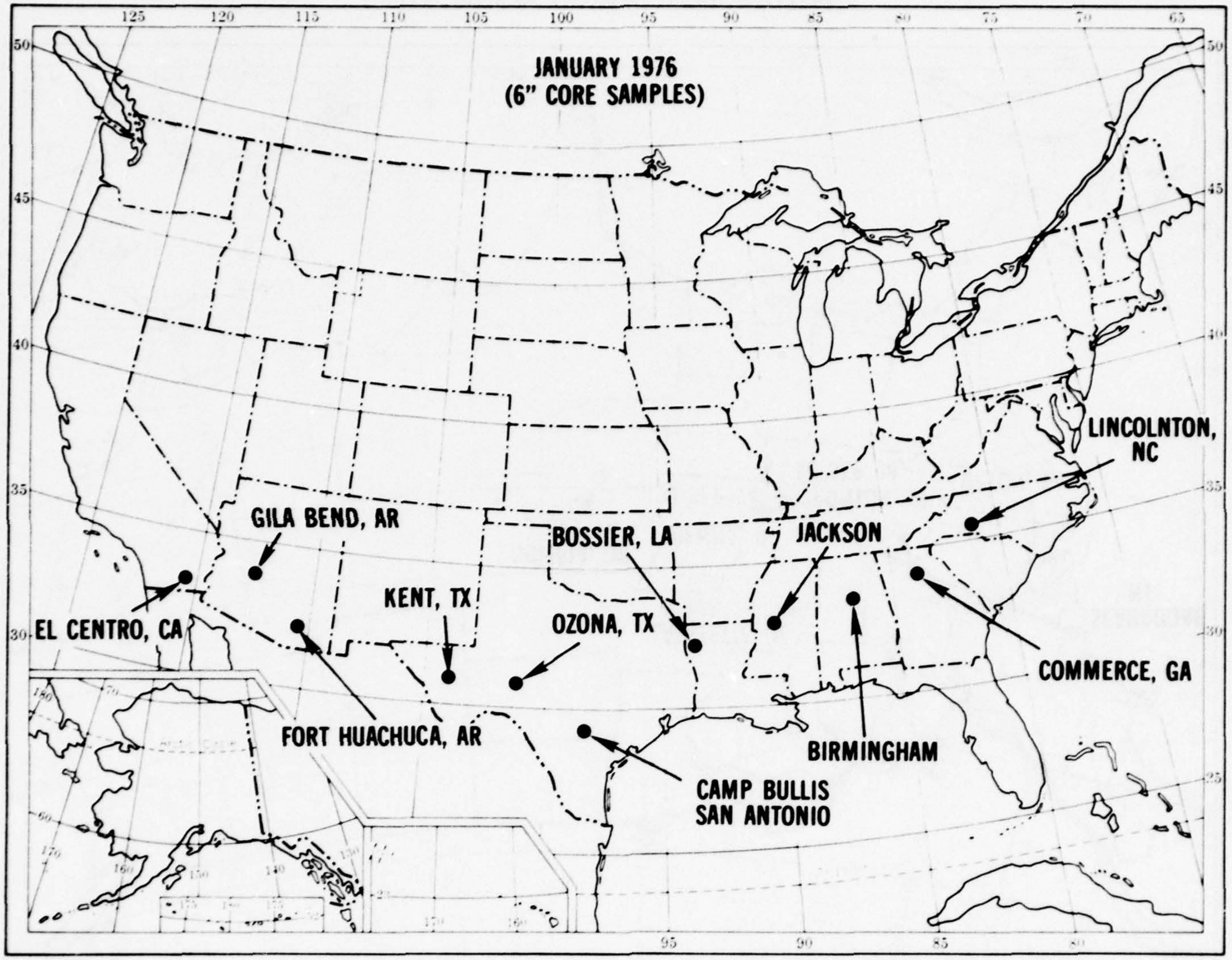

Figure 6. Locations at which core samples were taken in January 1976.

Table 7. Actual Field Moisture Compared with Forecasted Values

(January 1976 Survey)

Geographic Location	Actual Moisture Content 6" Core Samples as Determined in the Field		Computer Aided Moisture Forcast (Modified Penman – Budyko Equations)		Second Forecast Based Based on Actual Local Weather and Soil, "After the Fact"		Local Weather and Remarks
	Bare Soil Surface (%)	Vegetative Soil (%)	Bare Soil Surface (%)	Vegetative Soil (%)	Bare Soil Surface (%)	Vegetative Soil (%)	
Lincolnton, NC	13.3	12.5	10.3 ± 1.4	9.9 ± 1.3	–	–	Rain
Commerce, GA	18.9	16.3	16.6 ± 3.2	15.4 ± 2.6	–	–	Lt Rain
Birmingham, AL	21.6	19.8	20.6 ± 0.8	19.7 ± 0.7	–	–	Clear, Dry
Jackson, MS	26.8	21.8	22.5 ± 4.3	19.7 ± 4.1	–	–	Clear
Bossier, LA	28.0	20.5	18.1 ± 1.1	18.1 ± 1.1	–	–	Clear, Swampy Area
Camp Bullis, TX (Fill Area)	8.2	–	8.9 ± 0.5	–	5.0 ± 0.5	–	Reported to be a Dry Fall
Camp Bullis, TX (Natural)	37.5	35.8	12.0 ± 0.5	12.0 ± 0.5	–	–	Reported to be a Dry Fall
San Antonio, TX (SwRI)	–	20.7	–	12.1 ± 0.5	–	–	Reported to be a Dry Fall
Ozona, TX	23.0	16.0	4.4 ± 1.0	4.4 ± 1.0	–	–	Rain
Kent, TX	5.7	5.0	2.9 ± 0.7	2.6 ± 0.7	4.0 ± .1	4.0 ± .1	Clear
Gila Bend, AZ	6.0	5.0	1.4 ± 0.2	1.4 ± 0.2	4.5 ± .7	4.5 ± 0.7	Rain in Morning
Fort Huachuca, AZ	4.8	–	1.6 ± 0.5	–	6.5 ± 1.5	6.5 ± 1.5	Soil of Finer Texture
El Centro, CA	<1.0	<1.0	1.5 ± 0	1.5 ± 0	–	–	–

March 17, 1976

By the spring of 1976, research was started into locating areas which have great contrast in climate and soil textures over relatively short distances, i.e., Israel, Portugal, Kansas, and Puerto Rico. Puerto Rico was an ideal place to study the changes in several soil properties because of the great differences in rainfall, relief, vegetation, and parent rock. The island offered an ideal test bed to evaluate the forecasting method. The selection of the route for the field tests was guided by information supplied by a US Department of Agriculture Survey of Puerto Rico published in January 1942. This report indicated exactly the soil texture, rainfall, and depth to bed rock in a North-South (N-S) section of the island (Figures 7 and 8). Figure 7 shows the rainfall to range from moderate to heavy on the north side to light on the south side. The types of soils expected on this N-S section are shown in Figure 8. This information used in conjunction with highway information resulted in selecting ten locations: (1) Vega Alta, (2) Morovis (3) Orocovis, (4) Barranquitas, (5) Coamo, (6) Santa Isabel, (7) Pastillo, (8) Parguera, (9) Ensenada, and (10) Lajas (Figure 9). The results, showing the forecasted and actual soil moisture, are shown in Table 8.

Finally, as a result of an informal agreement between the Netherlands and the United States in 1974, a field test covering several seasons of the year 1976 was conducted by a Dutch team trained by MERADCOM personnel and led by LT. Lexden Hollander. This team utilized the soil in-situ kit for measuring the electromagnetic properties of the soil. The locations of the test areas in the Netherlands are shown in Figure 10. The field moisture values obtained by LT. Lexden Hollander's team compared with the forecasted moisture values appear in Table 9. The electromagnetic properties of the several locations are indicated in Table 10. At present, there is no data available in the computer data file for peat/sand soils.

6. Statistical Analysis of Field Data Taken at Fort Huachuca, Arizona, and Fort Belvoir, Virginia. During early June 1977, a series of side-looking radar experiments associated with minefields was conducted at Fort Huachuca, Arizona. Six months previously, there was concern as to the amount of soil moisture present at this location. (Yuma, Arizona, a much drier and thus a more desirable location, was ruled out as the test area for fiscal and aircraft logistical reasons.) A Terrain Forecast Program was employed at Fort Huachuca to find out what month was lowest in soil moisture, permittivity, and attenuation at this location. If the experiment were to have any chance of success, it required that the near surface (0 to 10 cm) of the chosen locations be as dry as possible under the prevailing climatological conditions. The program predicted that the end of June would be the driest season at Fort Huachuca. At that time, the soil would have a moisture content of 2.6% ± 2.0% (Table 11).

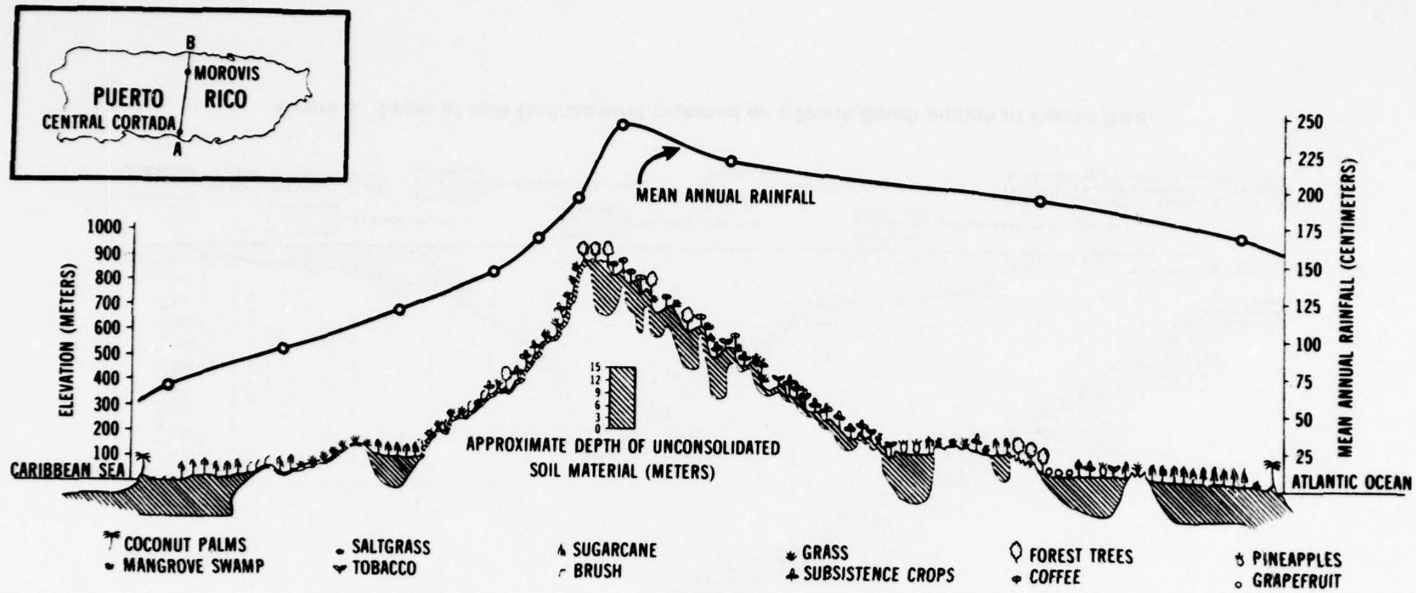

Figure 7. Rainfall and depth to bedrock on a North-South section of Puerto Rico.

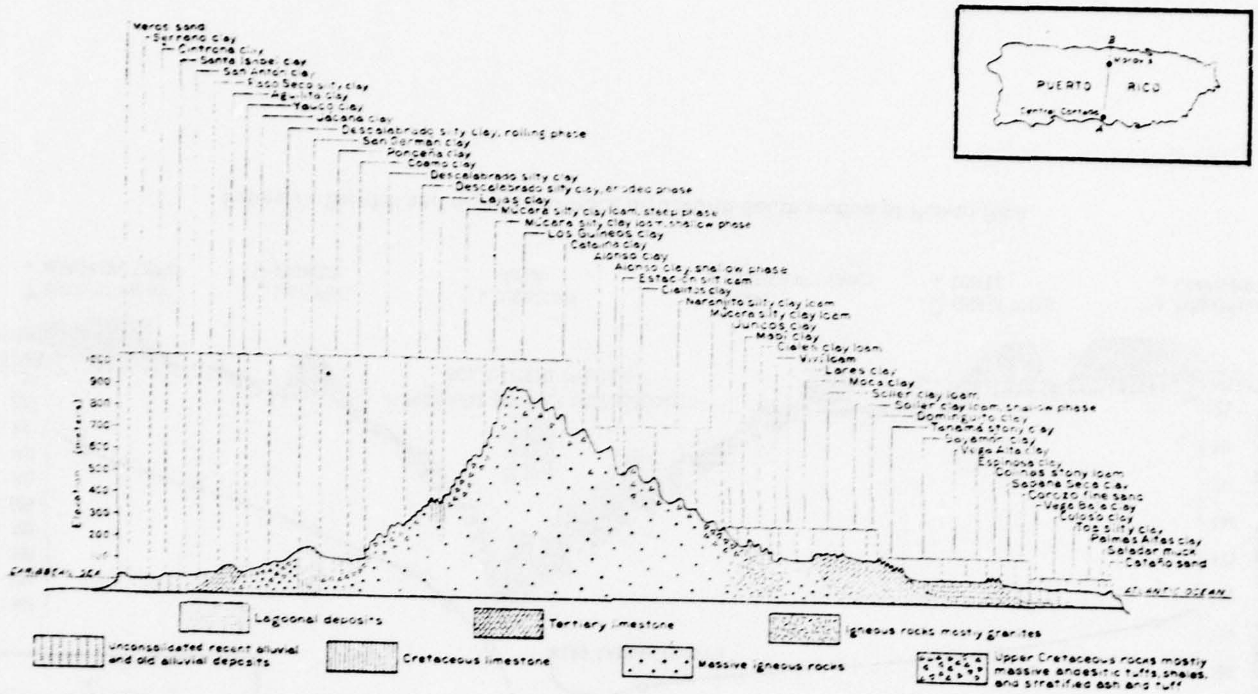

Figure 8. Types of soils (soil texture) expected on a North-South section of Puerto Rico.

Figure 9. Locations at which soil samples were taken in June 1976.

Table 8. Forecasted and Actual Soil Moisture at Ten Locations in Puerto Rico

(June 23 to 26, 1976)

Location in Puerto Rico	Forecasted Properties		Actual Values of Moisture and Texture Encountered in Field	
	Soil Moisture (%)	Texture	Soil Moisture (%)	Texture
Vega Alta	17.1 ± 2.8	Clay	25.9	Loamy Clay
Morovis	20.9 ± 4.3	Clay	17.6	Loamy Clay
Orocovis	30.1 ± 1.8	Clay	14.5	Sandy Loam
Barranquitas	30.2 ± 4.6	Clay	31.3	Clay
Coamo	10.4 ± 1.6	Clay	13.0	Clay
Santa Isabel	3.1 ± 0.9	Sand	5.7	Sandy Loam/Fine Sand
Pastillo	10.3 ± 1.4	Clay	13.4	Clay
Parguera	8.5 ± 0.6	Clay	9.8	Clay
Ensenada	8.6 ± 1.3	Clay	8.6	Clay
Lajas	12.0 ± 2.1	Clay	9.2	Clay

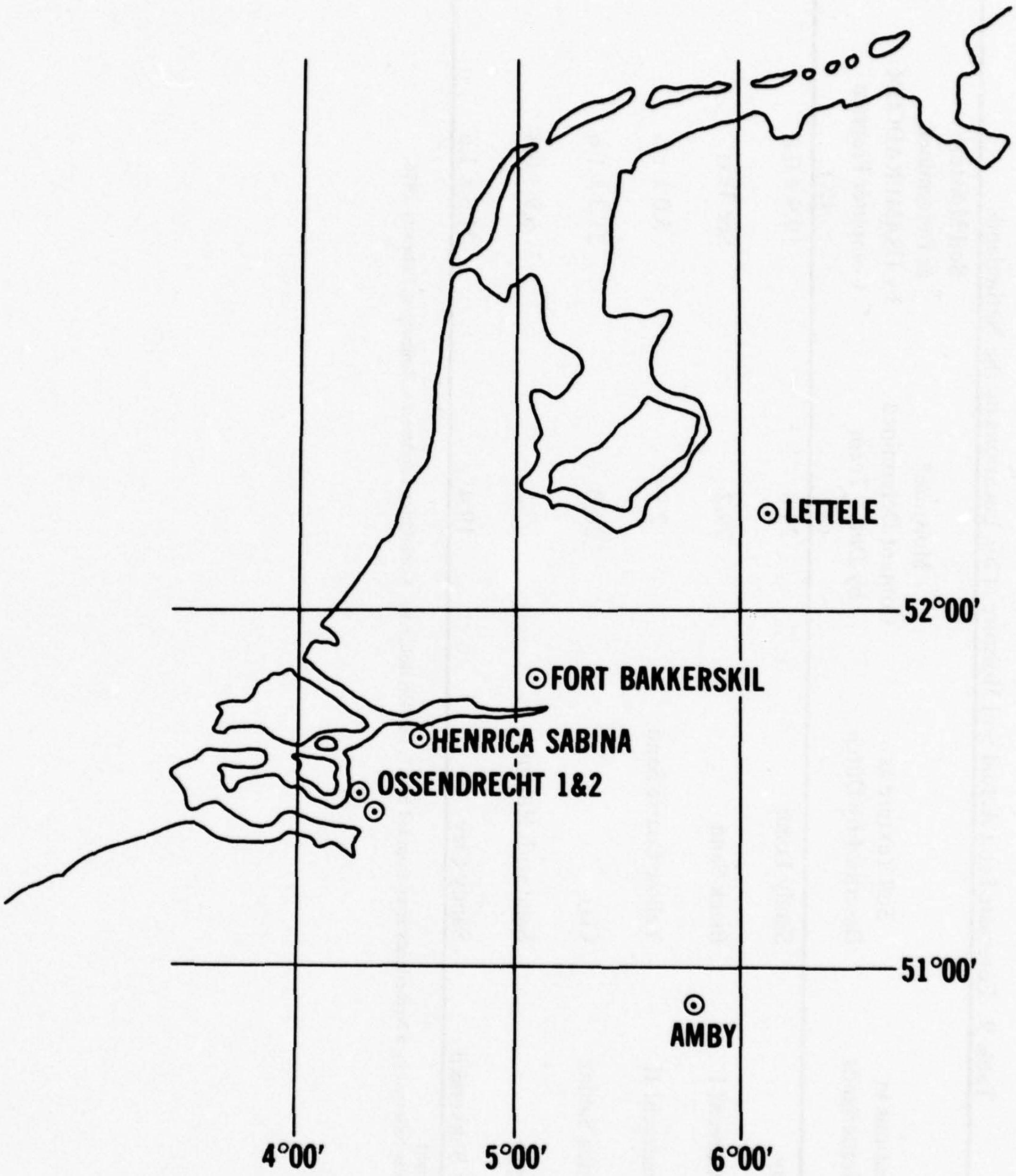

Figure 10. Test locations used by Dutch Team for in-situ soil measurements.

Table 9. Forecasted and Actual Soil Moisture at Six Locations in the Netherlands

Locations in The Netherlands	Soil Texture as Described by Dutch	Moisture* Content Determined by Dutch Team (%)	Soil Moisture as Determined by USAMERADCOM Computer Program (%)
Amby	Sandy Loam	24.8	19.9 ± 0.8
Ossendrecht I	Black Sand	29.2	See Text
Ossendrecht II	Yellow Coarse Sand	2.9	5.0 ± 1.6
Henrica Sabina	Clay	20.0	21.3 ± 1.6
Lettele	Sand with Humus	7.5	6.9 ± 0.8
Fort Bakkerskil	Sandy Clay	19.4	21.3 ± 1.6

* Percent dry weight.

Note: The data was collected by a Netherlands army team led by LT. Lexden Hollander, Koninklijke Landmacht, Huijbergen, February 1976.

Table 10. Electromagnetic Properties of the Soil at Six Locations in the Netherlands

Location in the Netherlands	Soil Texture as Classified by USAMERADCOM	E-M Properties of Dutch Soil Surface as Forecasted by Computer Program			
		300 MHz	500 MHz	1000 MHz	2000 MHz
Amby	Loess Soil	41 dB/m ± 2.1 ϵ_R = 17 ± 1.3	53 dB/m ± 2.4 ϵ_R = 15.5 ± 1.2	92 dB/m ± 5.2 ϵ_R = 14.5 ± 1.1	136 dB/m ± 7.4 ϵ_R = 12.9 ± 1.0
Ossendrecht I	Peat with Some Sand	No Data Available, at Present, for This Type Soil.			
Ossendrecht II	Coarse Sand	5 dB/m ± ϵ_R = 4.4 ±	6 dB/m ± ϵ_R = 4.3 ±	12 dB/m ± ϵ_R = 4.1 ±	26 dB/m ± ϵ_R = 4.0 ±
Henrica Sabina	Light Clay	46 dB/m ± 6.0 ϵ_R = 19.9 ± 3.6	59 dB/m ± 7.4 ϵ_R = 18.1 ± 3.3	103 dB/m ± 13.9 ϵ_R = 16.9 ± 3.1	152 dB/m ± 19.9 ϵ_R = 15.0 ± 2.7
Lettele	Sand	6dB/m ± 1.0 ϵ_R = 5.6 ± 0.8	8 dB/m ± 1.0 ϵ_R = 5.3 ± 0.7	15 dB/m ± 1.8 ϵ_R = 5.0 ± 0.5	33 dB/m ± 3.5 ϵ_R = 4.9 ± 0.5
Fort Bakkerskil	Sandy Clay Loam	46 dB/m ± 6.0 ϵ_R = 19.9 ± 3.6	59 dB/m ± 7.4 ϵ_R = 18.8 ± 3.3	103 dB/m ± 13.9 ϵ_R = 16.9 ± 3.1	152 dB/m ± 19.9 ϵ_R = 15.0 ± 2.7

Note: The data was generated by computer program using as inputs the average climatological data for the Netherlands' locations.
Note: Permittivity = ϵ_R

Table 11. Forecast of Soil E-M Parameters at Fort Huachuca, Arizona

Ft. Huachuca, AZ — Bare Soil — Field Capacity (mm/1500 mm)
Silt Loam — 433.-514. mm/1500 mm
Field Capacity = 24%
Critical Moisture = 13.1%

Month	Moisture % by Wt. Standard Dev (%)	300 MHz ATTN/Epsilon Standard Dev dB/-	500 MHz ATTN/Epsilon Standard Dev dB/-	1 GHz ATTN/Epsilon Standard Dev dB/-	2 GHz ATTN/Epsilon Standard Dev dB/-
JAN	5.8	14./4.8	21./5.6	29./5.1	51./4.8
	2.4	4.8/1.2	7.3/1.1	9.8/1.0	13.4/.9
FEB	6.2	15./6.0	22./5.8	31./5.3	53./5.0
	2.5	4.9/1.3	7.4/1.2	9.9/1.0	12.9/1.0
MAR	5.7	14./5.8	20./5.6	29./5.1	50./4.8
	2.7	5.4/1.4	8.1/1.2	10.9/1.1	15.2/1.0
APR	4.6	12./5.3	17./5.1	24./4.7	43./4.4
	2.8	5.9/1.3	8.7/1.2	11.8/1.1	19.2/.9
MAY	3.4	9./4.7	13./4.5	19./4.2	35./4.0
	2.5	5.7/1.1	8.4/1.0	11.4/.9	19.4/.7
JUN	2.6	7./4.3	11./4.2	16./3.9	38./3.7
	2.0	4.7/.8	6.8/.8	9.3/.7	16.9/.5
JUL	4.6	12./5.2	17./5.0	24./4.6	44./4.3
	1.9	4.1/.9	6.1/.8	8.3/.7	13.0/.6
AUG	5.4	13./5.6	19./5.4	28./5.0	48./4.6
	2.4	4.9/1.2	7.3/1.1	9.8/.9	14.1/.9
SEP	4.4	11./5.2	16./5.0	23./4.6	42./4.3
	2.6	5.5/1.2	8.1/1.1	11.0/1.0	17.3/.8
OCT	4.0	10./5.0	15./4.8	22.	

NOTE: ATTN/Epsilon: Attenuation is E-M loss in dB per meter. Epsilon is calculated dielectric constant.

During the month of June, 21 soil samples were randomly taken at the "Radar Spoke" at Fort Huachuca. This area is roughly 1.0 by 0.5 kilometer. Preliminary research indicated that the surface soil at Fort Huachuca's "Radar Spoke" should be classified as a silt loam. The moisture content of the 21 samples is as follows:

Sample No.	Moisture Content (%)
1	1.9
2	1.40
3	2.50
4	1.50
5	3.00
6	5.8
7	2.10
8	1.10
9	2.00
10	2.00
11	3.2
12	2.47
13	4.7
14	4.97
15	2.46
16	1.10
17	3.4
18	1.20
19	3.00
20	3.29
21	3.25

The average value of soil moisture equaled 2.69%. The standard deviation was calculated as 1.34%. The kurtosis equaled 2.91. ("The kurtosis indicates the spread of the frequency curve. The kurtosis of a normally distributed curve should be 3.00. If the value exceeds 3.00, the distribution is less peaked than the normal curve; and, if it is less than 3.00, the distribution is more peaked."[12]) Therefore, the sampled area illustrated is very nearly normally distributed. The predictive program forecasted 2.60% ± 2.0% for June. The actual field data gave 2.69% ± 1.34%. Three soil moisture samples were obtained on September 15, 1977, with an average moisture of 4.53%. The forecast for this time of year indicated 4.90%.

[12] J. P. Cole and C. A. M. King, *Quantitative Geography*, John Wiley & Sons, 1970, p. 113.

The same sampling procedure was followed in August 1977 at Fort Belvoir, Virginia, except that the samples were taken from two smaller areas: a 200-meter by 120-meter clearing and a 60-meter by 3-meter road. The 21 samples taken in the clearing, a sandy to silty loam, had the following moisture content:

Sample No.	Moisture Content (%)
1	8.8
2	13.61
3	9.25
4	15.96
5	19.59
6	13.28
7	13.97
8	9.71
9	9.07
10	9.28
11	13.39
12	9.78
13	18.55
14	13.88
15	11.00
16	14.77
17	13.19
18	14.54
19	8.59
20	11.29
21	10.74

The average value of soil moisture in this area equaled 12.49%. The forecasted value was calculated as 13.95%. The standard deviation for the 21 samples equaled 3.15%. The kurtosis (2.65) is lower than the kurtosis of the Fort Huachuca area indicating a much less than normal distribution. The Forecast Program indicated a soil wetter by 1.46% (by dry weight).

The last area to be considered at Fort Belvoir was the gravel/sand road near the natural clearing (Range 5). The sample number was reduced to 17 because of the much smaller area – 60 by 3 meters. The soil-moisture readings from the surface down to 10 centimeters for the 17 samples are as follows:

Sample No.	Moisture Content (%)
1	0.57
2	2.10
3	5.74
4	0.70
5	1.83
6	2.91
7	2.65
8	2.56
9	4.50
10	4.25
11	0.71
12	4.40
13	0.83
14	3.20
15	0.63
16	0.62
17	0.51

In the road area, the average soil moisture was 2.28% with a standard deviation of 1.68%. The kurtosis (2.078) turned out to be the lowest of the three areas under discussion. The predictive soil moisture is listed as 1.7% ± 1.0% as compared with the average field moisture of 2.28% ± 1.68%.

Summarizing, then, in all three areas, field moisture average values fall within the forecasted values (Table 12). The smaller the area that is sampled, the more the histogram of soil moisture deviates from a normal curve.

Table 12. Summary of Forecasted Field Moisture Compared with Actual Field Moisture at Fort Huachuca and Fort Belvoir

Location	Forecasted (%)	Lack of Textural Confidence Number (%)	Actual Field Moisture (%)	Standard Deviation (%)
Fort Huachuca	2.60	± 2.08	2.69	± 1.34
Fort Belvoir 1	13.95	± 1.55	12.49	± 3.15
Fort Belvoir 2	1.7	± 1.00	2.28	± 1.68

III. CONCLUSIONS

7. **Conclusions.** It is concluded that:

a. The comparison of field and forecasted soil-moisture test results over the past several years indicates that the Terrain Forecast Program can be used to predict the moisture, E-M, and thermal properties of the near-soil surface in any part of the world where climate and soil textural information is available. This prediction capability has a probability value approaching 0.75.

b. The most pragmatic value that the research program has to offer is the ability to give an appreciation of the values of the E-M and thermal properties that are most likely to be present during the month of interest. The program is not concerned about "special" types of clay, i.e., impregnated with salt in very local areas, but in the mechanical definition of sand, silt, and clay. Definitions are based on sand-grain and clay-plate size.

c. Simple, random sampling of a visibly, even-textured soil over an area of approximately 0.5 square kilometer suggests that soil-moisture values follow approximately a normal distribution curve.

d. The soil properties of an entire country or continent can be printed in a matter of several minutes with the MERADCOM 6600 Computer.

e. Computer graphics should be investigated as a method of applying the predictive technique to such presentations as maps.

f. High-resolution satellite soil moisture data should be used as a reverse input to the program which can be modified to predict soil texture types of remote locations.

APPENDIX A

THE NETHERLANDS: A COMPUTER PRINTOUT OF

PREDICTED TERRAIN PROPERTIES

LEEUWARDEN PREDICTION OF SOIL PARAMETERS

LOAMY CLAY BARE SOIL FC

FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	18.8	39./15.5	50./14.1	86./13.2	127./11.8
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	19.8	40./15.4	52./14.9	90./13.9	133./12.4
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	20.1	41./15.7	52./15.2	91./14.2	134./12.6
	.1	.4/ .2	.5/ .2	.9/ .2	1.4/ .2
APR	18.8	39./15.5	50./14.1	86./13.2	127./11.8
	.1	.2/ .1	.1/ .1	.5/ .1	.7/ .1
MAY	16.4	35./13.4	48./12.3	77./11.4	114./10.3
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	14.1	32./11.5	45./10.6	69./ 9.8	102./ 8.8
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	13.4	31./10.9	44./10.1	66./ 9.3	98./ 8.4
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
AUG	13.9	32./11.3	45./10.5	68./ 9.7	101./ 8.7
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
SEP	14.0	32./11.4	45./10.5	68./ 9.7	101./ 8.8
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
OCT	15.0	34./12.3	46./11.3	72./10.5	107./ 9.4
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
NOV	16.5	36./13.6	48./12.4	78./11.5	115./10.3
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
DEC	18.0	37./14.8	49./13.5	83./12.6	123./11.2
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1

TOTAL RAIN 30.5PAN EVAP. 29.5 CRITICALMOIST.(MM) 400.-405.

JOURE
LOAMY CLAY
FC 28.2% CRIT. 21.3%

PREDICTION OF SOIL PARAMETERS
BARE SOIL

FC
530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	19.9	40./15.4	52./14.9	90./13.9	133./12.4
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	20.9	44./18.5	56./16.9	98./15.7	145./14.0
	.1	.5/ .3	.6/ .3	1.1/ .2	1.6/ .2
MAR	21.0	44./18.9	57./17.2	100./16.0	147./14.3
	.1	.5/ .3	.6/ .3	1.2/ .3	1.7/ .2
APR	19.6	40./15.2	51./14.7	89./13.7	131./12.3
	.1	.2/ .1	.2/ .1	.5/ .1	.7/ .1
MAY	16.9	36./13.9	48./12.7	79./11.8	117./10.6
	.1	.2/ .1	.2/ .1	.5/ .1	.7/ .1
JUN	14.4	33./11.8	45./10.8	70./10.1	104./ 9.1
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	13.5	32./11.0	44./10.2	67./ 9.4	99./ 8.5
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
AUG	13.8	32./11.2	44./10.3	67./ 9.6	100./ 8.5
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
SEP	13.8	32./11.2	44./10.3	68./ 9.6	100./ 8.6
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
OCT	14.9	33./12.2	46./11.2	72./10.4	106./ 9.3
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
NOV	16.5	36./13.6	48./12.4	78./11.5	115./10.4
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
DEC	18.1	38./14.9	50./13.6	83./12.6	123./11.3
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1

TOTAL RAIN 32.8PAN EVAP. 30.2 CRITICALMOIST.(MM) 400.-405.

HOORN
PREDICTION OF SOIL PARAMETERS
LOAMY CLAY
BARE SOIL
FC

FC 28.2% CRIT. 21.3%
530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	18.7 .1	38./15.4 .1/ .1	50./14.0 .1/ .1	86./13.1 .4/ .1	126./11.7 .6/ .1
FEB	19.5 .1	40./15.1 .2/ .1	51./14.7 .1/ .1	89./13.7 .4/ .1	131./12.2 .6/ .1
MAR	19.6 .1	40./15.2 .2/ .1	51./14.7 .1/ .1	89./13.7 .4/ .1	131./12.3 .6/ .1
APR	18.5 .1	38./15.2 .2/ .1	50./13.9 .1/ .1	85./13.0 .4/ .1	126./11.6 .6/ .1
MAY	16.3 .1	35./13.3 .2/ .1	47./12.2 .1/ .1	77./11.3 .4/ .1	113./10.2 .6/ .1
JUN	13.7 .1	32./11.1 .1/ .1	44./10.3 .1/ .1	67./ 9.5 .4/ .1	100./ 8.5 .6/ .1
JUL	12.3 .1	30./ 9.9 .1/ .1	43./ 9.2 .1/ .1	62./ 8.5 .4/ .1	92./ 7.7 .5/ .1
AUG	12.1 .1	30./ 9.8 .1/ .1	42./ 9.1 .1/ .1	61./ 8.4 .4/ .1	91./ 7.6 .5/ .1
SEP	12.7 .1	30./10.3 .1/ .1	43./ 9.5 .1/ .1	63./ 8.8 .3/ .1	94./ 8.0 .5/ .1
OCT	14.1 .1	32./11.5 .1/ .1	45./10.6 .1/ .1	69./ 9.8 .3/ .1	102./ 8.8 .5/ .1
NOV	15.8 .1	35./13.0 .1/ .1	47./11.9 .1/ .1	75./11.0 .4/ .1	111./ 9.9 .5/ .1
DEC	17.2 .1	37./14.2 .1/ .1	49./12.9 .1/ .1	80./12.0 .4/ .1	119./10.8 .6/ .1

TOTAL RAIN 29.4PAN EVAP. 30.4 CRITICALMOIST.(MM) 400.-405.

GEMERT PREDICTION OF SOIL PARAMETERS
LOAMY CLAY BARE SOIL FC
FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	17.1	36./14.1	48./12.8	80./12.0	118./10.7
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
FEB	18.3	38./15.0	50./13.7	84./12.8	124./11.4
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
MAR	18.4	38./15.1	50./13.8	84./12.9	125./11.5
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
APR	17.4	37./14.3	49./13.0	81./12.1	119./10.9
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
MAY	15.3	34./12.5	46./11.5	73./10.7	109./ 9.6
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.1	31./10.6	44./ 9.8	65./ 9.1	96./ 8.2
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	11.6	29./ 9.4	42./ 8.7	60./ 8.1	89./ 7.3
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
AUG	11.2	28./ 9.0	41./ 8.4	58./ 7.7	86./ 7.0
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
SEP	11.3	29./ 9.1	42./ 8.5	59./ 7.9	87./ 7.1
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
OCT	12.3	30./ 9.9	43./ 9.2	62./ 8.5	92./ 7.7
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
NOV	13.9	32./11.3	45./10.4	58./ 9.7	101./ 8.7
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
DEC	15.5	34./12.6	46./11.6	74./10.8	109./ 9.7
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1

TOTAL RAIN 27.3PAN EVAP. 31.2 CRITICALMOIST.(MM) 400.-405.

ERMELO

PREDICTION OF SOIL PARAMETERS

LOAMY CLAY

BARE SOIL

FC 28.2% CRIT. 21.3% — FC 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON TOLERANCE	1GHZ ATTN/EPSILON TOLERANCE	2GHZ ATTN/EPSILON TOLERANCE
JAN	18.2	58./15.0	50./13.7	84./12.7	124./11.4
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	19.3	59./15.9	51./14.4	88./13.5	129./12.0
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	19.3	59./15.9	51./14.5	88./13.5	130./12.1
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
APR	18.3	58./15.0	50./13.7	84./12.8	124./11.4
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAY	16.0	55./13.1	47./12.0	76./11.2	112./10.0
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.4	51./10.9	44./10.1	66./ 9.3	98./ 8.4
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	12.5	50./10.1	43./ 9.4	63./ 8.7	93./ 7.8
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
AUG	13.0	51./10.5	43./ 9.7	65./ 9.0	96./ 8.1
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
SEP	13.0	51./10.6	44./ 9.8	65./ 9.0	96./ 8.2
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
OCT	14.0	52./11.4	45./10.5	68./ 9.7	101./ 8.8
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
NOV	15.1	54./12.3	46./11.3	72./10.5	107./ 9.4
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
DEC	15.5	56./13.5	48./12.4	78./11.5	115./10.3
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1

TOTAL RAIN 29.6PAN EVAP. 30.7 CRITICALMOIST.(MM) 400.-405.

EELDE PREDICTION OF SOIL PARAMETERS
LOAMY CLAY BARE SOIL FC
FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	19.1 .1	39./15.7 .2/ .1	51./14.3 .1/ .1	87./13.3 .4/ .1	128./11.9 .6/ .1
FEB	19.9 .1	40./15.4 .2/ .1	52./15.0 .2/ .1	90./14.0 .5/ .1	133./12.5 .7/ .1
MAR	20.1 .1	41./15.8 .5/ .3	52./15.3 .6/ .3	91./14.3 1.1/ .2	135./12.7 1.6/ .2
APR	18.9 .1	39./15.6 .2/ .1	51./14.2 .1/ .1	86./13.2 .5/ .1	128./11.8 .7/ .1
MAY	16.7 .1	36./13.7 .2/ .1	48./12.5 .1/ .1	78./11.7 .4/ .1	116./10.5 .7/ .1
N	14.3 .1	33./11.6 .2/ .1	45./10.7 .1/ .1	69./ 9.9 .4/ .1	103./ 9.0 .6/ .1
JUL	13.4 .1	31./10.9 .1/ .1	44./10.0 .1/ .1	66./ 9.3 .4/ .1	98./ 8.4 .6/ .1
AUG	13.5 .1	32./11.0 .1/ .1	44./10.1 .1/ .1	67./ 9.4 .4/ .1	99./ 8.5 .5/ .1
SEP	13.5 .1	31./11.0 .1/ .1	44./10.1 .1/ .1	66./ 9.4 .4/ .1	99./ 8.5 .5/ .1
OCT	14.4 .1	33./11.7 .1/ .1	45./10.8 .1/ .1	70./10.0 .4/ .1	103./ 9.0 .5/ .1
NOV	15.8 .1	35./12.9 .1/ .1	47./11.8 .1/ .1	75./11.0 .4/ .1	111./ 9.9 .6/ .1
DEC	17.3 .1	37./14.2 .1/ .1	49./13.0 .1/ .1	81./12.1 .4/ .1	119./10.8 .6/ .1

TOTAL RAIN 30.9PAN EVAP. 29.9 CRITICALMOIST.(MM) 400.-405.

DEN HELDER PREDICTION OF SOIL PARAMETERS
LOAMY CLAY BARE SOIL FC
FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON TOLERANCE	1GHZ ATTN/EPSILON TOLERANCE	2GHZ ATTN/EPSILON TOLERANCE
JAN	18.4	38./15.2	50./13.8	85./12.9	125./11.5
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	19.2	39./15.8	51./14.4	87./13.5	129./12.0
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	19.3	39./15.9	51./14.5	88./13.5	130./12.1
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
APR	18.5	38./15.2	50./13.8	85./12.9	125./11.5
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAY	16.3	35./13.4	47./12.2	77./11.4	114./10.2
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.5	32./11.0	44./10.1	67./ 9.4	99./ 8.5
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	12.1	30./ 9.7	42./ 9.0	61./ 8.4	91./ 7.5
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
AUG	11.5	29./ 9.3	42./ 8.6	59./ 8.0	88./ 7.2
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
SEP	12.0	29./ 9.7	42./ 9.0	61./ 8.3	90./ 7.5
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
OCT	13.7	32./11.1	44./10.2	67./ 9.5	100./ 8.6
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
NOV	15.5	34./12.7	47./11.6	74./10.8	109./ 9.7
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
DEC	17.0	36./13.9	48./12.7	79./11.9	117./10.6
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1

TOTAL RAIN 28.0 PAN EVAP. 29.9 CRITICAL MOIST.(MM) 400.-405.

DEDEMSVAART PREDICTION OF SOIL PARAMETERS
LOAMY CLAY BARE SOIL FC
FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON TOLERANCE	1GHZ ATTN/EPSILON TOLERANCE	2GHZ ATTN/EPSILON TOLERANCE
JAN	19.0	39./15.7	51./14.3	87./13.3	128./11.9
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	19.9	40./15.4	52./14.9	90./13.9	133./12.5
	.1	.2/ .1	.2/ .1	.5/ .1	.7/ .1
MAR	20.0	40./15.6	52./15.1	91./14.1	134./12.6
	.1	.3/ .2	.4/ .2	.8/ .2	1.2/ .2
APR	18.7	38./15.4	50./14.0	85./13.1	126./11.7
	.1	.2/ .1	.1/ .1	.5/ .1	.7/ .1
MAY	16.3	35./13.4	47./12.2	77./11.4	114./10.2
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.9	32./11.3	45./10.4	68./ 9.7	101./ 8.7
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	13.5	31./10.9	44./10.1	66./ 9.4	99./ 8.5
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
AUG	13.9	32./11.3	45./10.4	68./ 9.6	101./ 8.7
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
SEP	13.7	32./11.2	44./10.3	67./ 9.5	100./ 8.6
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
OCT	14.6	33./11.9	45./10.9	71./10.2	105./ 9.2
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
NOV	15.9	35./13.0	47./11.9	75./11.1	111./ 9.9
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
DEC	17.3	37./14.2	49./13.0	81./12.1	119./10.9
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1

TOTAL RAIN 31.1POT EVAP. 30.2 CRITICALMOIST.(MM) 400.-405.

DE BILT PREDICTION OF SOIL PARAMETERS

LOAMY CLAY BARE SOIL FC

FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	18.5	39./15.2	50./13.9	85./12.9	125./11.6
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	19.5	40./15.1	51./14.6	88./13.6	131./12.2
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	19.6	40./15.1	51./14.7	89./13.7	131./12.2
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
APR	18.6	38./15.3	50./13.9	85./13.0	126./11.5
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAY	16.3	35./13.3	47./12.2	77./11.4	114./10.2
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.7	32./11.2	44./10.3	67./ 9.6	100./ 8.6
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	12.4	30./10.0	43./ 9.3	62./ 8.6	93./ 7.8
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
AUG	12.2	30./ 9.9	43./ 9.2	62./ 8.5	92./ 7.7
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
SEP	12.5	30./10.1	43./ 9.4	63./ 8.7	93./ 7.8
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
OCT	13.7	32./11.1	44./10.3	67./ 9.5	100./ 8.6
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
NOV	15.3	34./12.5	46./11.5	73./10.7	108./ 9.5
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
DEC	16.9	36./13.8	48./12.6	79./11.8	117./10.5
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1

TOTAL RAIN 30.1PAN EVAP. 31.0 CRITICALMOIST.(MM) 400.-405.

BUCHTEN — PREDICTION OF SOIL PARAMETERS

LOAMY CLAY — BARE SOIL — FC

FC 28.2% CRIT. 21.3% — 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	18.0	57./14.8	49./13.5	83./12.6	122./11.2
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	19.1	59./15.7	51./14.3	87./13.3	128./11.9
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	19.0	59./15.7	51./14.3	87./13.3	128./11.9
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
APR	17.7	57./14.6	49./13.3	82./12.4	121./11.1
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAY	15.0	55./13.1	47./12.0	76./11.1	112./10.0
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.9	52./11.3	45./10.4	68./ 9.7	101./ 8.7
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	12.4	50./10.0	43./ 9.3	62./ 8.6	93./ 7.8
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
AUG	12.7	50./10.3	43./ 9.5	64./ 8.8	94./ 8.0
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
SEP	13.1	51./10.7	44./ 9.9	65./ 9.1	97./ 8.3
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
OCT	13.7	52./11.1	44./10.2	67./ 9.5	100./ 8.6
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
NOV	14.8	53./12.1	46./11.1	71./10.3	106./ 9.3
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
DEC	15.3	55./13.3	47./12.2	77./11.4	113./10.2
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1

TOTAL RAIN 30.5PAN EVAP. 31.9 CRITICALMOIST.(MM) 400.-405.

BEEK PREDICTION OF SOIL PARAMETERS

LOAMY CLAY BARE SOIL FC

FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	18.6	38./15.3	50./13.9	85./13.0	126./11.6
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	19.6	40./15.2	51./14.7	89./13.7	131./12.3
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	19.6	40./15.2	51./14.7	89./13.7	131./12.3
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
APR	18.4	38./15.2	50./13.8	85./12.9	125./11.5
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAY	16.5	36./13.5	48./12.4	78./11.5	115./10.3
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	14.4	33./11.8	45./10.8	70./10.0	104./ 9.0
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	13.2	31./10.8	44./ 9.9	66./ 9.2	97./ 8.3
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
AUG	13.3	31./10.8	44./10.0	66./ 9.2	98./ 8.3
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
SEP	13.6	32./11.0	44./10.2	67./ 9.4	99./ 8.5
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
OCT	14.2	32./11.6	45./10.6	69./ 9.9	102./ 8.9
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
NOV	15.5	34./12.7	46./11.6	74./10.8	109./ 9.7
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
DEC	16.9	36./13.9	48./12.7	79./11.8	117./10.6
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1

TOTAL RAIN 31.3PAN EVAP. 30.8 CRITICALMOIST.(MM) 400.-405.

ANDEL PREDICTION OF SOIL PARAMETERS
LOAMY CLAY BARE SOIL FC
FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	17.6	37./14.5	49./13.2	82./12.3	121./11.0
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
FEB	18.7	38./15.4	50./14.0	85./13.1	126./11.7
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	18.8	39./15.5	50./14.1	86./13.1	127./11.7
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
APR	17.9	37./14.7	49./13.4	83./12.5	122./11.2
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAY	15.7	34./12.8	47./11.8	75./10.9	110./ 9.8
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.2	31./10.7	44./ 9.9	65./ 9.2	97./ 8.3
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	12.1	30./ 9.8	42./ 9.1	61./ 8.4	91./ 7.6
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
AUG	11.9	29./ 9.6	42./ 8.9	61./ 8.3	90./ 7.5
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
SEP	11.9	29./ 9.7	42./ 9.0	61./ 8.3	90./ 7.5
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
OCT	13.0	31./10.5	44./ 9.7	65./ 9.0	96./ 8.1
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
NOV	14.5	33./11.9	45./10.9	70./10.1	104./ 9.1
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
DEC	16.0	35./13.1	47./12.0	76./11.2	112./10.0
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1

TOTAL RAIN 28.6PAN EVAP. 31.2 CRITICALMOIST.(MM) 400.-405.

ALMEN PREDICTION OF SOIL PARAMETERS

LOAMY CLAY BARE SOIL FC

FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	17.6	57./14.5	49./13.2	82./12.3	121./11.0
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
FEB	18.6	58./15.3	50./14.0	85./13.0	126./11.7
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	18.7	59./15.4	50./14.1	86./13.1	127./11.7
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
APR	17.9	57./14.7	49./13.4	83./12.5	122./11.2
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAY	15.7	54./12.9	47./11.8	75./11.0	111./ 9.8
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.4	51./10.9	44./10.0	66./ 9.3	98./ 8.4
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	12.0	50./ 9.7	42./ 9.0	61./ 8.3	91./ 7.6
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
AUG	11.9	[illegible]9./ 9.5	42./ 8.9	61./ 8.2	90./ 7.5
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
SEP	12.1	50./ 9.8	42./ 9.1	61./ 8.4	91./ 7.6
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
OCT	13.1	51./10.7	44./ 9.8	65./ 9.1	97./ 8.2
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
NOV	14.6	53./11.9	45./11.0	71./10.2	105./ 9.2
	.1	.1/ .1	.1/ .1	.3/ .1	.5/ .1
DEC	16.0	55./13.1	47./12.0	76./11.2	112./10.0
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1

TOTAL RAIN 28.2PAN EVAP. 30.8 CRITICALMOIST.(MM) 400.-405.

WINTERSWIJK PREDICTION OF SOIL PARAMETERS
SAND BARE SOIL FC
FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.9	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.6	3./ 3.3	4./ 3.3	8./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.7	2./ 2.9	2./ 2.9	6./ 2.9	15./ 2.8
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
AUG	.5	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
SEP	.8	2./ 2.9	3./ 2.9	6./ 2.9	15./ 2.8
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
OCT	1.8	2./ 3.1	3./ 3.1	7./ 3.1	18./ 3.0
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
NOV	3.0	3./ 3.4	4./ 3.4	9./ 3.4	20./ 3.3
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
DEC	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.2	.2/ .1	.2/ .1	.3/ .1	.5/ .1

TOTAL RAIN 29.9PAN EVAP. 30.8 CRITICALMOIST.(MM) 3.- 4.

WAGENINGEN PREDICTION OF SOIL PARAMETERS
SAND BARE SOIL FC
FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.7	3./ 3.4	4./ 3.3	8./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.1	2./ 3.0	3./ 2.9	7./ 2.9	16./ 2.8
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.6	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
AUG	.7	2./ 2.9	2./ 2.9	6./ 2.9	15./ 2.8
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
SEP	.8	2./ 2.9	3./ 2.9	6./ 2.9	16./ 2.8
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
OCT	1.8	2./ 3.1	3./ 3.1	7./ 3.1	18./ 3.0
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
NOV	3.0	3./ 3.4	4./ 3.4	9./ 3.4	20./ 3.3
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
DEC	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.2	.2/ .1	.2/ .1	.3/ .1	.6/ .1

TOTAL RAIN 30.2PAN EVAP. 31.2 CRITICALMOIST.(MM) 3.- 4.

VLISSINGEN PREDICTION OF SOIL PARAMETERS
SAND BARE SOIL FC
FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	4.2 .4	4./ 3.7 .2/ .1	5./ 3.6 .3/ .1	10./ 3.6 .4/ .1	23./ 3.5 .8/ .1
FEB	4.2 .4	4./ 3.7 .3/ .1	5./ 3.6 .3/ .1	10./ 3.6 .5/ .1	23./ 3.5 .9/ .1
MAR	4.2 .4	4./ 3.7 .3/ .1	5./ 3.6 .3/ .1	10./ 3.6 .5/ .1	23./ 3.5 .9/ .1
APR	3.8 .4	4./ 3.6 .3/ .1	5./ 3.5 .3/ .1	10./ 3.5 .5/ .1	22./ 3.4 .9/ .1
MAY	2.7 .4	3./ 3.4 .3/ .1	4./ 3.3 .3/ .1	8./ 3.3 .5/ .1	20./ 3.2 .9/ .1
JUN	1.2 .4	2./ 3.0 .2/ .1	3./ 3.0 .3/ .1	7./ 3.0 .5/ .1	16./ 2.9 .8/ .1
JUL	.4 .2	1./ 2.8 .1/ .0	2./ 2.8 .1/ .0	6./ 2.8 .2/ .0	15./ 2.7 .4/ .0
AUG	.2 0.0	1./ 2.8 0.0/0.0	2./ 2.7 0.0/0.0	5./ 2.7 0.0/0.0	14./ 2.5 0.0/0.0
SEP	.6 .0	1./ 2.8 .0/ .0	2./ 2.8 .0/ .0	6./ 2.8 .0/ .0	15./ 2.7 .0/ .0
OCT	1.7 .0	2./ 3.1 .0/ .0	3./ 3.1 .0/ .0	7./ 3.1 .1/ .0	17./ 3.0 .1/ .0
NOV	2.9 .1	3./ 3.4 .1/ .0	4./ 3.3 .1/ .0	9./ 3.3 .1/ .0	20./ 3.2 .3/ .0
DEC	3.7 .2	3./ 3.6 .1/ .0	5./ 3.5 .2/ .0	10./ 3.5 .2/ .0	22./ 3.4 .4/ .0

TOTAL RAIN 27.3PAN EVAP. 30.7 CRITICALMOIST.(MM) 3.- 4.

VLIEGVELD TWENTHE PREDICTION OF SOIL PARAMETERS

SAND BARE SOIL FC

FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON TOLERANCE	1GHZ ATTN/EPSILON TOLERANCE	2GHZ ATTN/EPSILON TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.7	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.5	3./ 3.3	4./ 3.3	8./ 3.3	19./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
AUG	1.5	2./ 3.1	3./ 3.0	7./ 3.0	17./ 2.9
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
SEP	1.5	2./ 3.1	3./ 3.0	7./ 3.0	17./ 2.9
	.2	.1/ .0	.2/ .0	.2/ .0	.5/ .0
OCT	2.0	2./ 3.2	3./ 3.1	8./ 3.1	18./ 3.0
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
NOV	3.0	3./ 3.4	4./ 3.4	9./ 3.4	20./ 3.3
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
DEC	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1

TOTAL RAIN 30.2PAN EVAP. 30.4 CRITICALMOIST.(MM) 3.- 4.

ST. ANNALAND PREDICTION OF SOIL PARAMETERS

SAND BARE SOIL FC

FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	600MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.6	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.3	3./ 3.3	4./ 3.2	8./ 3.2	19./ 3.1
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	.7	2./ 2.9	2./ 2.9	6./ 2.9	15./ 2.8
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.3	1./ 2.8	2./ 2.8	6./ 2.8	14./ 2.7
	.1	.0/ .0	.0/ .0	.1/ .0	.1/ .0
AUG	.8	2./ 2.9	3./ 2.9	6./ 2.9	16./ 2.8
	.1	.0/ .0	.0/ .0	.1/ .0	.1/ .0
SEP	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.1	.0/ .0	.1/ .0	.1/ .0	.1/ .0
OCT	2.2	3./ 3.2	4./ 3.2	8./ 3.2	19./ 3.1
	.1	.1/ .0	.1/ .0	.1/ .0	.2/ .0
NOV	3.1	3./ 3.5	4./ 3.4	9./ 3.4	21./ 3.3
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
DEC	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0

TOTAL RAIN 28.0PAN EVAP. 30.8 CRITICALMOIST.(MM) 3.- 4.

POORTUGAAL PREDICTION OF SOIL PARAMETERS
SAND BARE SOIL FC
FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	100MHZ ATTN/EPSILON DB/Z TOLERANCE	500MHZ ATTN/EPSILON DB/Z TOLERANCE	1GHZ ATTN/EPSILON DB/Z TOLERANCE	2GHZ ATTN/EPSILON DB/Z TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.7	3./ 3.5	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.4	3./ 3.3	4./ 3.2	8./ 3.2	19./ 3.1
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.0	2./ 2.9	3./ 2.9	6./ 2.9	16./ 2.8
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.6	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
AUG	1.5	2./ 3.1	3./ 3.0	7./ 3.0	17./ 2.9
	.2	.1/ .0	.2/ .0	.2/ .0	.5/ .0
SEP	1.8	2./ 3.1	3./ 3.1	7./ 3.1	18./ 3.0
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
OCT	2.7	3./ 3.4	4./ 3.3	8./ 3.3	20./ 3.2
	.2	.1/ .0	.2/ .0	.2/ .0	.5/ .0
NOV	3.5	3./ 3.5	5./ 3.5	9./ 3.5	21./ 3.4
	.2	.2/ .1	.2/ .1	.3/ .1	.5/ .1
DEC	4.1	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.3	.2/ .1	.2/ .1	.4/ .1	.6/ .1

TOTAL RAIN 30.8PAN EVAP. 39.7 CRITICALMOIST.(MM) 3.- 4.

DUDE WETERING PREDICTION OF SOIL PARAMETERS

SAND BARE SOIL FC

FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.9	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.6	3./ 3.3	4./ 3.3	8./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.1	2./ 3.0	3./ 2.9	7./ 2.9	16./ 2.8
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.5	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.2	.2/ .1	.2/ .1	.3/ .1	.5/ .1
AUG	.5	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
SEP	1.3	2./ 3.0	3./ 3.0	7./ 3.0	17./ 2.9
	.2	.1/ .0	.1/ .0	.2/ .0	.3/ .0
OCT	2.5	3./ 3.3	4./ 3.3	8./ 3.3	19./ 3.2
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
NOV	3.5	3./ 3.6	5./ 3.5	9./ 3.5	22./ 3.4
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
DEC	4.1	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.3	.2/ .1	.3/ .1	.4/ .1	.7/ .1

TOTAL RAIN 30.5PAN EVAP. 30.5 CRITICALMOIST.(MM) 3.- 4.

OUDENBOSCH PREDICTION OF SOIL PARAMETERS
SAND BARE SOIL FC
FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	4.2 .4	4./ 3.7 .3/ .1	5./ 3.6 .3/ .1	10./ 3.6 .5/ .1	23./ 3.5 .9/ .1
FEB	4.2 .4	4./ 3.7 .3/ .1	5./ 3.6 .3/ .1	10./ 3.6 .5/ .1	23./ 3.5 .9/ .1
MAR	4.2 .4	4./ 3.7 .3/ .1	5./ 3.6 .3/ .1	10./ 3.6 .5/ .1	23./ 3.5 .9/ .1
APR	3.7 .4	3./ 3.6 .3/ .1	5./ 3.5 .3/ .1	10./ 3.5 .5/ .1	22./ 3.4 .9/ .1
MAY	2.6 .4	3./ 3.3 .3/ .1	4./ 3.3 .3/ .1	8./ 3.3 .5/ .1	20./ 3.2 .9/ .1
JUN	1.1 .4	2./ 3.0 .2/ .1	3./ 3.0 .3/ .1	7./ 3.0 .4/ .1	16./ 2.9 .8/ .1
JUL	.4 .2	1./ 2.8 .1/ .1	2./ 2.8 .2/ .1	6./ 2.8 .3/ .1	15./ 2.7 .5/ .1
AUG	.4 .2	1./ 2.8 .1/ .0	2./ 2.8 .1/ .0	6./ 2.8 .2/ .0	15./ 2.7 .4/ .0
SEP	.8 .1	2./ 2.9 .1/ .0	3./ 2.9 .1/ .0	6./ 2.9 .2/ .0	16./ 2.8 .3/ .0
OCT	1.9 .1	2./ 3.2 .1/ .0	3./ 3.1 .1/ .0	7./ 3.1 .2/ .0	18./ 3.0 .3/ .0
NOV	3.1 .2	3./ 3.4 .1/ .0	4./ 3.4 .1/ .0	9./ 3.4 .2/ .0	21./ 3.3 .4/ .0
DEC	3.8 .2	4./ 3.6 .2/ .1	5./ 3.5 .2/ .1	10./ 3.5 .3/ .1	22./ 3.4 .5/ .1

TOTAL RAIN 29.1PAN EVAP. 30.9 CRITICALMOIST.(MM) 3.- 4.

LEEUWARDEN PREDICTION OF SOIL PARAMETERS
SAND BARE SOIL FC
FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.7	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.5	3./ 3.3	4./ 3.3	8./ 3.3	19./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
AUG	2.0	2./ 3.2	3./ 3.1	8./ 3.1	18./ 3.0
	.2	.1/ .1	.2/ .1	.3/ .1	.5/ .1
SEP	2.1	2./ 3.2	4./ 3.2	8./ 3.2	18./ 3.1
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
OCT	2.9	3./ 3.4	4./ 3.3	9./ 3.3	20./ 3.2
	.2	.1/ .1	.2/ .1	.3/ .1	.5/ .1
NOV	3.7	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
DEC	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1

TOTAL RAIN 30.5PAN EVAP. 29.3 CRITICALMOIST.(MM) 3.- 4.

JOURE PREDICTION OF SOIL PARAMETERS
SAND BARE SOIL FC
FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.7	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.5	3./ 3.3	4./ 3.2	8./ 3.2	19./ 3.1
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	1.1	2./ 3.0	3./ 2.9	7./ 2.9	16./ 2.8
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
AUG	1.7	2./ 3.1	3./ 3.1	7./ 3.1	17./ 3.0
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
SEP	1.9	2./ 3.2	3./ 3.1	7./ 3.1	18./ 3.0
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
OCT	2.8	3./ 3.4	4./ 3.3	9./ 3.3	20./ 3.2
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
NOV	3.7	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
DEC	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1

TOTAL RAIN 32.8PAN EVAP. 30.0 CRITICALMOIST.(MM) 3.- 4.

HOORN PREDICTION OF SOIL PARAMETERS
SAND BARE SOIL FC
FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.7	3./ 3.3	4./ 3.3	8./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.1	2./ 3.0	3./ 2.9	7./ 2.9	16./ 2.8
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.4	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.2	.1/ .0	.1/ .0	.2/ .0	.3/ .0
AUG	.4	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.1	.1/ .0	.1/ .0	.1/ .0	.3/ .0
SEP	1.1	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.1	.1/ .0	.1/ .0	.1/ .0	.2/ .0
OCT	2.4	3./ 3.3	4./ 3.2	8./ 3.2	19./ 3.1
	.1	.1/ .0	.1/ .0	.2/ .0	.3/ .0
NOV	3.5	3./ 3.5	5./ 3.5	9./ 3.5	21./ 3.4
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
DEC	4.1	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1

TOTAL RAIN 29.4PAN EVAP. 30.2 CRITICALMOIST.(MM) 3.- 4.

GEMERT PREDICTION OF SOIL PARAMETERS

SAND BARE SOIL FC

FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	4.1	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.3	.2/ .1	.2/ .1	.4/ .1	.6/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.7	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.6	3./ 3.3	4./ 3.3	8./ 3.3	19./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.1	2./ 3.0	3./ 2.9	7./ 2.9	16./ 2.8
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.2	1./ 2.8	2./ 2.8	5./ 2.8	14./ 2.7
	.0	.0/ .0	.0/ .0	.0/ .0	.1/ .0
AUG	.2	1./ 2.8	2./ 2.7	5./ 2.7	14./ 2.6
	0.0	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0
SEP	.3	1./ 2.8	2./ 2.8	6./ 2.8	14./ 2.7
	.0	.0/ .0	.0/ .0	.0/ .0	.0/ .0
OCT	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.0	.0/ .0	.0/ .0	.0/ .0	.1/ .0
NOV	2.5	3./ 3.3	4./ 3.3	8./ 3.3	19./ 3.2
	.1	.1/ .0	.1/ .0	.1/ .0	.2/ .0
DEC	3.4	3./ 3.5	5./ 3.5	9./ 3.5	21./ 3.4
	.2	.1/ .0	.1/ .0	.2/ .0	.3/ .0

TOTAL RAIN 27.3PAN EVAP. 31.1 CRITICALMOIST.(MM) 3.- 4.

ERMELO PREDICTION OF SOIL PARAMETERS
SAND BARE SOIL FC
FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.7	3./ 3.3	4./ 3.3	8./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.0	2./ 2.9	3./ 2.9	6./ 2.9	16./ 2.8
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.6	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
AUG	1.3	2./ 3.0	3./ 3.0	7./ 3.0	17./ 2.9
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
SEP	1.4	2./ 3.0	3./ 3.0	7./ 3.0	17./ 2.9
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
OCT	2.3	3./ 3.2	4./ 3.2	8./ 3.2	19./ 3.1
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
NOV	3.0	3./ 3.4	4./ 3.4	9./ 3.4	20./ 3.3
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
DEC	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1

TOTAL RAIN 29.6PAN EVAP. 30.5 CRITICALMOIST.(MM) 3.- 4.

EELOE
SAND
FC 4.2% CRIT. .1%

PREDICTION OF SOIL PARAMETERS
BARE SOIL

FC
90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	4.2 .4	4./ 3.7 .3/ .1	5./ 3.6 .3/ .1	10./ 3.6 .5/ .1	23./ 3.5 .9/ .1
FEB	4.2 .4	4./ 3.7 .3/ .1	5./ 3.6 .3/ .1	10./ 3.6 .5/ .1	23./ 3.5 .9/ .1
MAR	4.2 .4	4./ 3.7 .3/ .1	5./ 3.6 .3/ .1	10./ 3.6 .5/ .1	23./ 3.5 .9/ .1
APR	3.8 .4	4./ 3.6 .3/ .1	5./ 3.5 .3/ .1	10./ 3.5 .5/ .1	22./ 3.4 .9/ .1
MAY	2.8 .4	3./ 3.4 .3/ .1	4./ 3.3 .3/ .1	9./ 3.3 .5/ .1	20./ 3.2 .9/ .1
JUN	1.4 .4	2./ 3.0 .2/ .1	3./ 3.0 .3/ .1	7./ 3.0 .4/ .1	17./ 2.9 .8/ .1
JUL	1.2 .3	2./ 3.0 .2/ .1	3./ 3.0 .2/ .1	7./ 3.0 .3/ .1	16./ 2.9 .6/ .1
AUG	1.6 .2	2./ 3.1 .1/ .1	3./ 3.1 .2/ .1	7./ 3.1 .3/ .1	17./ 3.0 .5/ .1
SEP	1.7 .2	2./ 3.1 .1/ .1	3./ 3.1 .2/ .0	7./ 3.1 .3/ .0	18./ 3.0 .5/ .0
OCT	2.5 .2	3./ 3.3 .1/ .1	4./ 3.2 .2/ .0	8./ 3.2 .3/ .0	19./ 3.1 .5/ .0
NOV	3.4 .2	3./ 3.5 .2/ .1	5./ 3.4 .2/ .1	9./ 3.4 .3/ .1	21./ 3.3 .5/ .1
DEC	4.1 .3	4./ 3.7 .2/ .1	5./ 3.6 .2/ .1	10./ 3.6 .4/ .1	23./ 3.5 .6/ .1

TOTAL RAIN 30.9PAN EVAP. 29.7 CRITICALMOIST.(MM) 3.- 4.

DEN HELDER PREDICTION OF SOIL PARAMETERS

SAND BARE SOIL FC

FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.9	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.8	3./ 3.4	4./ 3.3	9./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.0	2./ 2.9	3./ 2.9	6./ 2.9	16./ 2.8
	.4	.2/ .1	.3/ .1	.5/ .1	.9/ .1
JUL	.3	1./ 2.8	2./ 2.8	6./ 2.8	14./ 2.7
	.0	.0/ .0	.0/ .0	.1/ .0	.1/ .0
AUG	.2	1./ 2.8	2./ 2.7	5./ 2.7	14./ 2.6
	0.0	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0
SEP	.7	2./ 2.9	2./ 2.9	6./ 2.9	15./ 2.8
	.0	.0/ .0	.0/ .0	.0/ .0	.0/ .0
OCT	2.2	3./ 3.2	4./ 3.2	8./ 3.2	19./ 3.1
	.1	.0/ .0	.1/ .0	.1/ .0	.1/ .0
NOV	3.4	3./ 3.5	5./ 3.5	9./ 3.5	21./ 3.4
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
DEC	4.0	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.2	.2/ .1	.2/ .1	.3/ .1	.6/ .1

TOTAL RAIN 28.0PAN EVAP. 29.7 CRITICALMOIST.(MM) 3.- 4.

DEDEMSVAART PREDICTION OF SOIL PARAMETERS

SAND BARE SOIL FC

FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.7	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.6	3./ 3.3	4./ 3.3	8./ 3.3	19./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	1.3	2./ 3.0	3./ 3.0	7./ 3.0	17./ 2.9
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
AUG	1.9	2./ 3.2	3./ 3.1	8./ 3.1	18./ 3.0
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
SEP	2.0	2./ 3.2	3./ 3.1	8./ 3.1	18./ 3.0
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
OCT	2.7	3./ 3.3	4./ 3.3	8./ 3.3	20./ 3.2
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
NOV	3.4	3./ 3.5	5./ 3.5	9./ 3.5	21./ 3.4
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
DEC	4.1	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.3	.2/ .1	.2/ .1	.4/ .1	.7/ .1

TOTAL RAIN 31.1PAN EVAP. 30.0 CRITICALMOIST.(MM) 3.- 4.

DE BILT PREDICTION OF SOIL PARAMETERS
SAND BARE SOIL FC
FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1 9.5-10.5	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.7	3./ 3.4	4./ 3.3	8./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.5	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1
AUG	.6	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
SEP	.9	2./ 2.9	3./ 2.9	6./ 2.9	16./ 2.8
	.2	.1/ .0	.1/ .0	.2/ .0	.3/ .0
OCT	2.0	2./ 3.2	4./ 3.1	8./ 3.1	18./ 3.0
	.2	.1/ .0	.1/ .0	.2/ .0	.3/ .0
NOV	3.2	3./ 3.5	4./ 3.4	9./ 3.4	21./ 3.3
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
DEC	3.9	4./ 3.6	5./ 3.6	10./ 3.6	22./ 3.5
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1

TOTAL RAIN 30.1PAN EVAP. 30.8 CRITICALMOIST.(MM) 3.- 4.

BUCHTEN PREDICTION OF SOIL PARAMETERS

SAND BARE SOIL FC

FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.6	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.8	3./ 3.4	4./ 3.3	9./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.6	2./ 3.1	3./ 3.1	7./ 3.1	17./ 3.0
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.6	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.3	.2/ .1	.2/ .1	.4/ .1	.7/ .1
AUG	1.1	2./ 3.0	3./ 2.9	7./ 2.9	16./ 2.8
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
SEP	1.6	2./ 3.1	3./ 3.1	7./ 3.1	17./ 3.0
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
OCT	2.1	2./ 3.2	4./ 3.2	8./ 3.2	18./ 3.1
	.2	.1/ .0	.2/ .0	.2/ .0	.4/ .0
NOV	2.9	3./ 3.4	4./ 3.3	9./ 3.3	20./ 3.2
	.2	.1/ .0	.2/ .0	.2/ .0	.5/ .0
DEC	3.7	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1

TOTAL RAIN 30.5PAN EVAP. 31.7 CRITICALMOIST.(MM) 3.- 4.

BEEK PREDICTION OF SOIL PARAMETERS

SAND BARE SOIL FC

FC 4.2% CRIT. .1% 90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON TOLERANCE	1GHZ ATTN/EPSILON TOLERANCE	2GHZ ATTN/EPSILON TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.7	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.8	3./ 3.4	4./ 3.3	9./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.7	2./ 3.1	3./ 3.1	7./ 3.1	18./ 3.0
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.3	.2/ .1	.2/ .1	.4/ .1	.7/ .1
AUG	1.5	2./ 3.1	3./ 3.0	7./ 3.0	17./ 2.9
	.2	.1/ .1	.2/ .1	.3/ .1	.5/ .1
SEP	1.8	2./ 3.1	3./ 3.1	7./ 3.1	18./ 3.0
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
OCT	2.4	3./ 3.3	4./ 3.2	8./ 3.2	19./ 3.1
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
NOV	3.2	3./ 3.5	4./ 3.4	9./ 3.4	21./ 3.3
	.2	.2/ .1	.2/ .1	.3/ .1	.5/ .1
DEC	3.9	4./ 3.6	5./ 3.6	10./ 3.6	22./ 3.5
	.3	.2/ .1	.2/ .1	.3/ .1	.6/ .1

TOTAL RAIN 31.3PAN EVAP. 30.8 CRITICALMOIST.(MM) 3.- 4.

ANDEL
SAND
FC 4.2% CRIT. .1%

PREDICTION OF SOIL PARAMETERS
BARE SOIL

FC
90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.7	3./ 3.3	4./ 3.3	8./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.0	2./ 2.9	3./ 2.9	6./ 2.9	16./ 2.8
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.4	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0
AUG	.4	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
SEP	.5	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.1	.1/ .0	.1/ .0	.2/ .0	.3/ .0
OCT	1.5	2./ 3.1	3./ 3.0	7./ 3.0	17./ 2.9
	.1	.1/ .0	.1/ .0	.2/ .0	.3/ .0
NOV	2.8	3./ 3.4	4./ 3.3	9./ 3.3	20./ 3.2
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
DEC	3.6	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0

TOTAL RAIN 28.6PAN EVAP. 31.1 CRITICALMOIST.(MM) 3.- 4.

ALMEN
SAND
FC 4.2% CRIT. .1%

PREDICTION OF SOIL PARAMETERS
BARE SOIL

FC
90.-110.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON TOLERANCE	1GHZ ATTN/EPSILON TOLERANCE	2GHZ ATTN/EPSILON TOLERANCE
JAN	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
FEB	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAR	4.2	4./ 3.7	5./ 3.6	10./ 3.6	23./ 3.5
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
APR	3.8	4./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
MAY	2.7	3./ 3.3	4./ 3.3	8./ 3.3	20./ 3.2
	.4	.3/ .1	.3/ .1	.5/ .1	.9/ .1
JUN	1.2	2./ 3.0	3./ 3.0	7./ 3.0	16./ 2.9
	.4	.2/ .1	.3/ .1	.4/ .1	.8/ .1
JUL	.4	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.2	.1/ .0	.1/ .0	.2/ .0	.4/ .0
AUG	.4	1./ 2.8	2./ 2.8	6./ 2.8	15./ 2.7
	.1	.1/ .0	.1/ .0	.2/ .0	.3/ .0
SEP	.7	2./ 2.9	2./ 2.9	6./ 2.9	15./ 2.8
	.1	.1/ .0	.1/ .0	.1/ .0	.3/ .0
OCT	1.7	2./ 3.1	3./ 3.1	7./ 3.1	17./ 3.0
	.1	.1/ .0	.1/ .0	.1/ .0	.3/ .0
NOV	2.8	3./ 3.4	4./ 3.3	9./ 3.3	20./ 3.2
	.2	.1/ .0	.1/ .0	.2/ .0	.3/ .0
DEC	3.6	3./ 3.6	5./ 3.5	10./ 3.5	22./ 3.4
	.2	.1/ .1	.2/ .0	.3/ .0	.5/ .0

TOTAL RAIN 28.2PAN EVAP. 30.7 CRITICALMOIST.(MM) 3.- 4.

ST. ANNALAND PREDICTION OF SOIL PARAMETERS
LOAMY CLAY BARE SOIL FC
FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON TOLERANCE	500MHZ ATTN/EPSILON DB TOLERANCE	1GHZ ATTN/EPSILON DB TOLERANCE	2GHZ ATTN/EPSILON DB TOLERANCE
JAN	17.9 .1	37./14.7 .1/ .1	49./13.4 .1/ .1	82./12.5 .4/ .1	122./11.2 .6/ .1
FEB	18.7 .1	38./15.4 .1/ .1	50./14.0 .1/ .1	86./13.1 .4/ .1	127./11.7 .6/ .1
MAR	18.6 .1	38./15.4 .1/ .1	50./14.0 .1/ .1	85./13.0 .4/ .1	126./11.7 .6/ .1
APR	17.5 .1	37./14.4 .2/ .1	49./13.1 .1/ .1	81./12.2 .4/ .1	120./11.0 .6/ .1
MAY	15.2 .1	34./12.4 .1/ .1	46./11.4 .1/ .1	73./10.6 .4/ .1	108./ 9.5 .6/ .1
JUN	12.9 .1	31./10.5 .1/ .1	43./ 9.7 .1/ .1	64./ 9.0 .4/ .1	96./ 8.1 .6/ .1
JUL	11.9 .1	29./ 9.6 .1/ .1	42./ 8.9 .1/ .1	61./ 8.2 .4/ .1	90./ 7.5 .5/ .1
AUG	12.3 .1	30./10.0 .1/ .1	43./ 9.2 .1/ .1	62./ 8.5 .3/ .1	92./ 7.7 .5/ .1
SEP	12.6 .1	30./10.2 .1/ .1	43./ 9.4 .1/ .1	63./ 8.7 .3/ .1	94./ 7.9 .5/ .1
OCT	13.8 .1	32./11.2 .1/ .1	44./10.4 .1/ .1	68./ 9.6 .3/ .1	100./ 8.7 .5/ .1
NOV	15.1 .1	34./12.4 .1/ .1	46./11.3 .1/ .1	72./10.5 .3/ .1	107./ 9.5 .5/ .1
DEC	16.3 .1	35./13.4 .1/ .1	47./12.3 .1/ .1	77./11.4 .4/ .1	114./10.2 .5/ .1

TOTAL RAIN 28.0PAN EVAP. 30.8 CRITICALMOIST.(MM) 400.-405.

POORTUGAAL PREDICTION OF SOIL PARAMETERS
LOAMY CLAY BARE SOIL FC
FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	18.9	39./15.6	51./14.2	86./13.2	128./11.8
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	19.9	40./15.4	52./14.9	90./13.9	133./12.4
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	19.7	40./15.3	51./14.8	89./13.8	132./12.3
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
APR	18.5	38./15.2	50./13.9	85./12.9	125./11.6
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAY	16.0	35./13.1	47./12.0	76./11.2	112./10.0
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.6	32./11.1	44./10.2	67./ 9.5	99./ 8.5
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	12.7	30./10.3	43./ 9.5	64./ 8.8	94./ 8.0
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
AUG	13.4	31./10.9	44./10.0	66./ 9.3	98./ 8.4
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
SEP	13.6	32./11.1	44./10.2	67./ 9.5	99./ 8.5
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
OCT	14.7	33./12.0	46./11.0	71./10.2	105./ 9.2
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
NOV	16.0	35./13.1	47./12.0	76./11.2	112./10.0
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
DEC	17.3	37./14.2	49./13.0	80./12.1	119./10.8
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1

TOTAL RAIN 30.8PAN EVAP. 30.7 CRITICALMOIST.(MM) 400.-405.

OUDE WETERING PREDICTION OF SOIL PARAMETERS
LOAMY CLAY BARE SOIL FC
FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	300MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	18.9	39./15.5	51./14.2	86./13.2	128./11.8
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	19.9	40./15.4	52./14.9	90./13.9	133./12.4
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	19.9	40./15.4	52./14.9	90./13.9	133./12.4
	.1	.2/ .1	.2/ .1	.5/ .1	.7/ .1
APR	18.9	39./15.5	51./14.2	86./13.2	128./11.8
	.1	.2/ .1	.1/ .1	.4/ .1	.7/ .1
MAY	16.5	35./13.5	48./12.3	77./11.5	114./10.3
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.9	32./11.3	45./10.4	68./ 9.7	101./ 8.7
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	12.6	31./10.2	43./ 9.5	63./ 8.8	94./ 7.9
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
AUG	12.4	30./10.0	43./ 9.3	62./ 8.6	93./ 7.8
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
SEP	13.0	31./10.6	44./ 9.8	65./ 9.1	96./ 8.2
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
OCT	14.4	33./11.8	45./10.8	70./10.1	104./ 9.1
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
NOV	16.1	35./13.2	47./12.1	76./11.2	112./10.1
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
DEC	17.5	37./14.3	49./13.1	81./12.2	120./10.9
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1

TOTAL RAIN 30.5PAN EVAP. 30.5 CRITICALMOIST.(MM) 400.-405.

URK PREDICTION OF SOIL PARAMETERS
LOAMY CLAY BARE SOIL FC
FC 28.2% CRIT. 21.3% 530.-540.

MONTH	MOISTURE %BY WT. TOLERANCE	100MHZ ATTN/EPSILON DB/TOLERANCE	500MHZ ATTN/EPSILON DB/TOLERANCE	1GHZ ATTN/EPSILON DB/TOLERANCE	2GHZ ATTN/EPSILON DB/TOLERANCE
JAN	18.7	38./15.4	50./14.0	86./13.1	126./11.7
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
FEB	19.7	40./15.3	51./14.8	89./13.8	132./12.3
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
MAR	20.0	40./15.5	52./15.0	90./14.0	134./12.5
	.1	.3/ .2	.3/ .2	.7/ .1	1.0/ .1
APR	18.8	39./15.5	50./14.1	86./13.1	127./11.7
	.1	.2/ .1	.1/ .1	.4/ .1	.7/ .1
MAY	15.4	35./13.4	48./12.3	77./11.4	114./10.3
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUN	13.9	32./11.3	45./10.4	68./ 9.7	101./ 8.7
	.1	.2/ .1	.1/ .1	.4/ .1	.6/ .1
JUL	13.3	31./10.8	44./10.0	66./ 9.3	98./ 8.4
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1
AUG	13.7	32./11.2	44./10.3	67./ 9.5	100./ 8.6
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
SEP	13.7	32./11.1	44./10.3	67./ 9.5	100./ 8.6
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
OCT	14.5	33./11.8	45./10.8	70./10.1	104./ 9.1
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
NOV	15.7	34./12.8	47./11.7	74./10.9	110./ 9.8
	.1	.1/ .1	.1/ .1	.4/ .1	.5/ .1
DEC	17.1	36./14.0	48./12.8	80./11.9	118./10.7
	.1	.1/ .1	.1/ .1	.4/ .1	.6/ .1

TOTAL RAIN 30.5PAN EVAP. 29.9 CRITICALMOIST.(MM) 400.-405.

APPENDIX B

THE MAIN COMPUTER PROGRAM

```
      PROGRAM MST4 (INPUT=65,OUTPUT=65,TAPE1=INPUT,TAPE2=OUTPUT,
     C PORT,TAPE4=PORT,TAPE9)
C     THIS IS THE THIRD VERSION OF MST3
C     EDITION OF 12/75
      DIMENSION LOC(2),EVAP(12),TEM(12),RAIN(12),SURF(12)
      DIMENSION RAIN2(12)
      DIMENSION FCAP(2),CRIT(2)
      COMMON/IUN/IU
      PRINT*,"  LOCAL OR REMOTE L=LOC R=REM"
      READ(1,5) KI
      IF(KI.EQ.1HR) IU=9
      IF(KI.NE.1HR) IU=2
      REWIND 4
      REWIND 9
         CALL CONNEC(5LINPUT)
         CALL CONNEC(6LOUTPUT)

2       CONTINUE
      CALL READD(TEM,RAIN,LOC)
         CALL PRELM(LOC,LAT,TEM,RAIN,SURF,RAIN2,TOTAL,HEMI)
         CALL BASIC(EVAP,TEM,RAIN,LAT,TEVAP)
      CALL INDEX(HEMI,TOTAL,TEVAP,I)
      CALL ETRN(I,SURF)
3        CALL TYPE(ITEX,MODE,FCAP,CRIT)
      F=(FCAP(1)+FCAP(2))/2.
      G=(F/15.)*RATIO(ITEX)
      D=(CRIT(1)+CRIT(2))/2.
      E=(D/15.)*RATIO(ITEX)
13      CONTINUE
         CALL FORM(1,MODE,LOC,G,E,FCAP,ITEX,TOTAL,TEVAP)
      CAPL=FCAP(1)
      CAPH=FCAP(2)
        DO 10 IA=1,132
```

```
420=         CALL HEAV(IA,RAIN,EVAP,FCAP,CAPL,CAPH,CRIT,SURF,MODE,
430=     CRAIN2,ITEX)
440=10      CONTINUE
450=         CALL FORM(2,MODE,LOC,G,E,CRIT,ITEX,TOTAL,TEVAP)
455=      CALL FORM1(1,MODE,LOC,G,E,CRIT,ITEX,TOTAL,
456=     CTEVAP)
460=         CALL THERM(G)
470=       IF(MODE-3)8,7,7
480=7     MODE=2
490=      GO TO 13
500=8     WRITE(2,9)
510=9     FORMAT(6(/),'+DO YOU WANT TO CHANGE THE LOCATION AND DATA?

520=       IF (NYES1(N))20,8,2
530=20    WRITE(2,87)
540=87    FORMAT (' DO YOU WANT TO QUIT?  ')

550= 5    FORMAT(A10)
560=       IF(NYES1(N))3,20,98
570=98    STOP
580=99    E  N  D
590=      SUBROUTINE HEAV(IA,RAIN,EVAP,FCAP,CAPL,CAPH,CRIT,
600=     CSURF,MODE,RAIN2,ITEX)
610=      DIMENSION FCAP(2),CRIT(2),AM(12)
620=      DIMENSION A(4),AD(4),E(4),ED(4)
630=      DIMENSION RAIN(12),EVAP(12),SURF(12),RAIN2(12)
640=      COMMON/MOIS/AM
650=      COMMON/IUN/IU
660=C     PART OF THE NEW MOISTURE PROGRAM  12/75  L.M.
670=C
680=      IB=IA
690=33     IF(IB-12)64,64,45
700=45    IB=IB-12
```

```
      GO TO 33
64     IF(IA-121)68,15,15
15       CALL MONTH(IB)
68     IF(MODE-2)1,2,1
1     S=.63
      GO TO 3
2     S=SURF(IB)
3        CALL CALC(IB,EVAP,RAIN,FCAP(1),CAPL,CRIT(1),S)
C
         CALL CALC(IB,EVAP,RAIN,FCAP(2),CAPH,CRIT(2),S)
       IF(IA.EQ.121)K=0
       IF(IA-121)105,104,104
104   PWA=(CAPL/15.)*RATIO(ITEX)
      PWB=(CAPH/15.)*RATIO(ITEX)
      K=K+1
      PW=(PWA+PWB)/2.
      AM(K)=PW

      PWD=ABS((PWB-PWA)/2.)
        DO 20 J=1,4
      A(J)=(ALPHA(ITEX,PWA,J)+ALPHA(ITEX,PWB,J))/2.
      AD(J)=ABS((ALPHA(ITEX,PWA,J)-ALPHA(ITEX,PWB,J))/2.)
      E(J)=(EPSIL(ITEX,PWA,J)+EPSIL(ITEX,PWB,J))/2.
      ED(J)=ABS((EPSIL(ITEX,PWB,J)-EPSIL(ITEX,PWA,J))/2.)
       IF(AD(J)-A(J))20,19,19
19    A(1)=-1.
20       CONTINUE
       IF(EVAP(IB))51,51,52
52     IF(A(1))22,22,21
21    WRITE(IU,7)PW,A(1),E(1),A(2),E(2),A(3),E(3),A(4),E(4)
7     FORMAT(1H+,7X,F4.1,2X,4(5X,F4.0"/"F4.1))
```

```
      WRITE(IU,8)PWD,AD(1),ED(1),AD(2),ED(2),AD(3),ED(3),AD(4)
     C   ,ED(4)
8     FORMAT(1H ,8X,F4.1,1X,4(6X,F4.1"/"F3.1))
      GO TO 108
22    WRITE (IU,80)PW,PWD
80    FORMAT(1H+,12X,F4.1,/,8X,F4.1,7X," NO RELIABLE DATA "
     C"AVAILABLE FOR THIS MOISTURE")
      GO TO 108
51    WRITE(IU,90)PW,PWD
90    FORMAT(1H+,12X,F4.1,/," ICE",4X,F4.1,7X," NO RELIABLE "
     C "DATA AVAILABLE FOR ICE")
108   RAIN(IB)=RAIN2(IB)
      WRITE(IU,49)
49    FORMAT(1X)
105     CONTINUE

      RETURN
      E  N  D
      SUBROUTINE TYPE(ITEX,MODE,FCAP,CRIT)
      DIMENSION FCAP(2),CRIT(2)
      COMMON/IUN/IU
7     WRITE(2,1)
1     FORMAT(" SAND, SANDY LOAM, SILT LOAM, LOAMY CLAY, "
     C"CLAY   ? ")
        CALL STYPE(ITEX)
       IF(ITEX)7,7,4
4     WRITE(2,2)
2     FORMAT(" ENTER LOW & HIGH EACH OF FIELD CAPACITY AND CRIT"
     C"ICAL VALUE",/)
      READ(1,*)FCAP(1),FCAP(2),CRIT(1),CRIT(2)
      WRITE(IU,8) FCAP(1),FCAP(2),CRIT(1),CRIT(2)
```

```
8     FORMAT(*  LOW FC =*,F5.0,*  HIGH FC =*,F5.0,
     C * LOW CRIT =*,F5.0,* HIGH CRIT =*F5.0/)
5     WRITE (2,3)
3     FORMAT(' BARE SOIL, VEGETATION, BOTH    ?  ')
        CALL COVER(MODE)
       IF(MODE)5,5,6
6     RETURN
      E   N   D
      SUBROUTINE COVER(ITYPE)
      COMMON/IUN/IU
      READ(1,1)I
1     FORMAT(A3)
       IF(I.EQ.3HBAR)GO TO 10
       IF(I.EQ.3HVEG)GO TO 20
       IF(I.EQ.3HBOT)GO TO 30
      ITYPE=-1

      RETURN
10    ITYPE=1
      WRITE(IU,15)
15    FORMAT(*  THIS OUTPUT IS FOR BARE SOIL*)
      RETURN
20    ITYPE=2
      WRITE(IU,25)
25    FORMAT(* THIS OUTPUT IS WITH GRASS COVER*)
      RETURN
30    ITYPE=3
      WRITE(IU,35)
35    FORMAT(* THESE OUTPUTS ARE FOR BARE AND GRASS COVER*)
      RETURN
      E   N   D
      SUBROUTINE FORM(I,MODE,LOC,G,E,FRIT,ITEX,TOTAL,TEVAP)
```

```
1620=        DIMENSION FRIT(2),LOC(2)
1630=        COMMON/IUN/IU
1640=C
1650=C       12/75 L.M.
1660=         IF(I-1)1,1,2
1670=1       WRITE(IU,3)LOC
1680=3       FORMAT(1H1,3(/),1X,2A10,2X,'PREDICTION OF SOIL PARAMETERS')
1690=         CALL TEX(ITEX)
1700=         IF(MODE-2)20,10,20
1710=10      WRITE(IU,11)
1720=11      FORMAT(1H+,28X,'UNDER VEGETATION'19X'FC')
1730=        GO TO 6
1740=20      WRITE(IU,21)
1750=21      FORMAT(1H+,31X,'BARE SOIL',24X,'FC')
1760=6       WRITE(IU,30)G,E,FRIT(1),FRIT(2)
1770=30      FORMAT(' FC',F6.1,'%',2X,'CRIT.   'F6.1,'%',34X,

1780=       CF4.0,'-',F4.0,2(/),' MONTH  MOISTURE',
1790=       C6X,6H300MHZ,8X,6H500MHZ,9X,4H1GHZ,10X,4H2GHZ
1800=       C/,9X,'%BY WT.',1X,4('  ATTN/EPSILON')  1810=      C,/,6X,' TOL
ERANCE'4X,4(' TOLERANCE       '),/
1820=       C,1H+,10X,'%',10X,4(4HDB/-,10X,),/)
1830=        RETURN
1840=2       WRITE(IU,40)TOTAL,TEVAP,FRIT(1),FRIT(2)
1850=40      FORMAT (2(/),'+TOTAL RAIN',F5.1,'PAN EVAP. ',F5.1,8X,'CRITICA
L'
1860=       C'MOIST.(MM) ',F4.0,'-',F4.0)
1870=        RETURN
1880=        E  N  D
1890=        SUBROUTINE PRELM(LOC,LAT,TEM,RAIN,SFD,RAIN2,TOTAL,HEMI)
1900=        DIMENSION LOC(2),TEM(12),RAIN(12),SFD
```

```
        COMMON/IUN/IU
C       PART OF THE THIRD VERSION OF MST4
C          12/75 L.M.
        WRITE(2,4)
4       FORMAT(' WHAT IS THE LATATUDE?  ')
        READ(1,*)LAT
        WRITE(IU,5)
 5      FORMAT(1H1)
        WRITE(IU,3) LAT
 3      FORMAT(*  LATITUDE IS *,I2/)
        WRITE(2,21)
 21     FORMAT(* WHAT IS THE HEMISPHERE?*)
        READ(1,22)HEMI
 22     FORMAT(A5)
        TOTAL=0
12        DO 10 I=1,12
16      RAIN2(I)=RAIN(I)
        TOTAL=TOTAL+RAIN(I)
10        CONTINUE

        RETURN
        E   N   D
        FUNCTION NYES1(N)
        READ 900,ICAA
900     FORMAT(A1)
         IF(ICAA.EQ.1HY)GO TO 10
         IF(ICAA.EQ.1HN)GO TO 20
        NYES1=0
        RETURN
10      NYES1=1
        RETURN
20      NYES1=-1
        RETURN
```

```
L,2230,2500
 2230=       E   N   D
 2240=       SUBROUTINE CALC(IB,EVAP,RAIN,FCAP,CAP,CRIT,SURF)
 2250=C  PART OF MST4 SYSTEM, THIS SUB CALCULATES THE SOIL MOISTURE
 2260=C  AT THE END OF A PERIOD USING EVAPORATION AND RAINFALL INPUTS
 2270=C  AFTER THE METHOD OF BUDYKO AND PENMAN.
 2280=C  L.M.  9/75
 2290=       DIMENSION RAIN(12),EVAP(12)
 2300=       E=EVAP(IB)*SURF
 2310=       RANE=RAIN(IB)*25.4
 2320=       B=.8*RANE/(E+RANE)
 2330=       C=2.+B*(RANE/FCAP)
 2340=       D=C+EVAP(IB)/CRIT
 2350=        IF(CAP-CRIT)102,103,103
 2360= 102   W3=(RANE+2.*CAP)/D
 2370=       W2=W3
 2380=       GO TO 68

 2390=103    W2=(RANE+(2.*CAP)-E)/C
 2400=68     W4=(2.*W2)-CAP
 2410=        IF(W4-FCAP)13,13,14
 2420=14     W4=FCAP
 2430=13      IF(W4-5.)76,71,71
 2440=76     W4=5.
 2450=71     CAP=W4
 2460=       RETURN
 2470=       E   N   D
 2480=       SUBROUTINE EXTRA(WET,S,L,ALPHA)
 2490=C  PART OF MST4 SYSTEM, USED BY ALPHA AND EPSIL
 2500=C  TO LINIARLY EXTRAPOLATE DATA
```

```
C  L.M.   9/75
C  12/75
      DIMENSION S(5,9)
       IF(WET-S(5,1))10,10,15
10    I=1
20     IF(WET-S(I,1))11,12,13
13    I=I+1
      GO TO 20
12    ALPHA=S(I,L)
      RETURN
11    I=I-1
      DIF=S(I+1,1)-S(I,1)
      ADIF=S(I+1,L)-S(I,L)
      BDIF=WET-S(I,1)
      R=BDIF/DIF
      ALPHA=S(I,L)+R*ADIF
      RETURN
15    ALPHA=-1
      RETURN

      E   N   D
      FUNCTION ALPHA(ITEX,WET,IFREQ)
C  PART OF MST4 SYSTEM SUPPLIES VALUES TO ALPHA (ATTENUATION)
C  LM  9/75
C  12/75
      COMMON/DATA/D1(5,9),D2(5,9),D3(5,9),D4(5,9)
     C,D5(5,9),D6(12,12)
```

```
      M=IFREQ*2
      GO TO (100,200,300,400,500)ITEX
100      CALL EXTRA(WET,D1,M,ALPHA)
      RETURN
200      CALL EXTRA(WET,D2,M,ALPHA)
      RETURN
300      CALL EXTRA(WET,D3,M,ALPHA)
      RETURN
400      CALL EXTRA(WET,D4,M,ALPHA)
      RETURN
500      CALL EXTRA(WET,D5,M,ALPHA)
      RETURN
      E  N  D
      FUNCTION EPSIL(ITEX,WET,IFREQ)
C  PART OF MST4 SYSTEM, SUPPLIES VALUES TO EPSIL  (DIELECTRIC
C  CONSTANT)   L.M.  9/75
C   12/75
      COMMON/DATA/D1(5,9),D2(5,9),D3(5,9),D
4(5,9)
     C,D5(5,9),D6(12,12)
      M=(IFREQ*2)+1
      GO TO (100,200,300,400,500)ITEX
100      CALL EXTRA(WET,D1,M,EPSIL)
      RETURN
200      CALL EXTRA(WET,D2,M,EPSIL)
      RETURN
300      CALL EXTRA(WET,D3,M,EPSIL)
      RETURN
400      CALL EXTRA(WET,D4,M,EPSIL)
      RETURN
```

```
500     CALL EXTRA(WET,D5,M,EPSIL)
      RETURN
      E   N   D
      SUBROUTINE BASIC(EVAP,TEM,RAIN,LAT,TEVAP)
C  PART OF MST4 SYSTEM
C  COMPUTES THE EVAPORATION,AVERAGE TEMP.AND TOTAL RAIN.
C  NOV 1975  LM
      COMMON/IUN/IU
      DIMENSION EVAP(12),TEM(12),RAIN(12)
      YI=0
        DO 17 I=1,12
      T=(TEM(I)-32.)/1.8
       IF(T)19,12,12
19    T=0
12    YI=YI+(T/5.)**1.514
      TEM(I)=T
17      CONTINUE

      A=((.675*YI**3)-(77.*YI**2)+(17920.*YI)+492390.)*1.E-6
      TEVAP=0
        DO 18 I=1,12
      EV=18.936*(10.*TEM(I)/YI)**A
      EVAP(I)=EV*SUNDR(I,LAT)/(SUNDR(I,0)-.2)
      TEVAP=TEVAP+(EVAP(I)/25.4)
         CALL MONTH(I)
      WRITE(IU,14)EVAP(I)
14    FORMAT(1H+,6X,"EVAP.   ",F6.1)
18      CONTINUE
      RETURN
```

```
3340=        E   N   D
3350=        SUBROUTINE TEX(ITEX)
3360=C  PART OF MST4 SYSTEM, WRITES THE WORDS SAND,SANDY LOAM ETC.
3370=C  L.M.   9/75
3380=        COMMON/IUN/IU
3390=        GO TO (1,2,3,4,5)ITEX
3400=1       WRITE(IU,11)
3410=        RETURN
3420=2       WRITE(IU,12)
3430=        RETURN
3440=3       WRITE(IU,13)
3450=        RETURN
3460=4       WRITE(IU,14)
3470=        RETURN
3480=5       WRITE(IU,15)
3490=        RETURN
3500=11      FORMAT (' SAND      ')
3510=12      FORMAT (' SANDY LOAM')

3520=13      FORMAT (' SILT LOAM ')
3530=14      FORMAT (' LOAMY CLAY')
3540=15      FORMAT (' CLAY      ')
3550=        E   N   D
3560=        FUNCTION RATIO(ITEX)
3570=C  PART OF MST4 SYSTEM, SUPPLIES A VALUE FOR RATIO WHICH IS
3580=C  THE RATIO OF PERCENTAGE MOISTURE BY WEIGHT TO PERCENTAGE
3590=C  MOISTURE BY VOLUME.
3600=C  L.M.   9/75
3610=        GO TO (1,2,3,4,5)ITEX
3620=1       RATIO=.633
```

```
3630=        RETURN
3640=2       RATIO=.693
3650=        RETURN
3660=4       RATIO=.792
3670=        RETURN
3680=3       RATIO=.760
3690=        RETURN
3700=5       RATIO=.826
3710=        RETURN
3720=        E    N    D
3730=        SUBROUTINE MONTH (I)
3740=C   PART OF MST4 SYSTEM, THIS SUB PRINTS A MONTH NAME FROM
3750=C   A INTERER INPUT.
3760=C   L.M.    9/75
3770=        COMMON/IUN/IU
3780=        GO TO (1,2,3,4,5,6,7,8,9,10,11,12) I
3790=1       WRITE(IU,21)
3800=        RETURN

3810=2       WRITE(IU,22)
3820=        RETURN
3830=3       WRITE(IU,23)
3840=        RETURN
3850=4       WRITE(IU,24)
3860=        RETURN
3870=5       WRITE(IU,25)
3880=        RETURN
3890=6       WRITE(IU,26)
3900=        RETURN
3910=7       WRITE(IU,27)
```

```
       RETURN
8      WRITE(IU,28)
       RETURN
9      WRITE(IU,29)
       RETURN
10     WRITE(IU,30)
       RETURN
11     WRITE(IU,31)
       RETURN
12     WRITE(IU,32)
       RETURN
21     FORMAT (' JAN ')
22     FORMAT (' FEB ')
23     FORMAT (' MAR ')
24     FORMAT (' APR ')
25     FORMAT (' MAY ')
26     FORMAT (' JUN ')
27     FORMAT (' JUL ')
28     FORMAT (' AUG ')

29     FORMAT (' SEP ')
30     FORMAT (' OCT ')
31     FORMAT (' NOV ')
32     FORMAT (' DEC ')
       E   N   D
       FUNCTION SUNDR(MONTH,LAT)
C  PART OF MST4 SYSTEM,L.M. 12/75
       COMMON/DATA/D1(5,9),D2(5,9),D3(5,9),D4(5,9),D5(5,9),
      CD6(12,12)
2      ILAT=LAT+50
```

```
      JLAT=ILAT/10+1
      KLAT=JLAT+1
      IUNIT=ILAT-(10*(JLAT-1))
      UNIT =IUNIT
      DIFF=D6(MONTH,KLAT)-D6(MONTH,JLAT)
      SUNDR=D6(MONTH,JLAT)+(UNIT*DIFF/10.)
      RETURN
      E   N   D
      BLOCK DATA SOILD
      COMMON/DATA/D1(5,9),D2(5,9),D3(5,9),D4(5,9),D5(5,9),
     CD6(12,12)
      DATA D1/
     C    0.,5.,10.,20.,20.,1.1,4.3,10.,13.7,13.7,2.7
     C,   3.9,8.5,23.4,23.4,1.9,5.9,12.,13.7,13.7,2.7
     C,   3.8,78,23.4,23.4,5.2,11.2,22.,30.,30.,2.7,3.8,7.,19.2
     C,   19.2,13.7,24.8,45.5,61.5,61.5,2.6,3.7,6.9,19.,19.
     C/
      DATA D2/
     C    0.,5.,10.,20.,20.,1.1,7.3,14.2,15.2,15.2,2.9,4.4,8.4
     C,   22.8,22.8,1.9,10.3,19.,20.2,20.2,2.8,4.3,7.7,21.,21.
     C,   4.6,16.2,30.,32.,32.,2.8,4.1,7.,19.,19.,12.,33.6,54.1,58.
     C,   58.,2.7,3.9,6.7,18.2,18.2
     C/
      DATA D3/
     C    0.,5.,10.,20.,28.,1.3,13.,22.2,25.,36.6,3.3,5.2,8.1,18.
     C,   28.,1.9,19.,33.,34.,44.,3.2,5.1,7.6,17.,26.5,3.7,27.
     C,   45.7,49.,72.2,3.,4.7,6.9,16.,25.,8.6,51.,71.4,77.,113.
```

```
4480=     C,   3.,4.3,6.5,15.,23.5
4490=     C/
4500=      DATA D4/
4510=     C    0.,5.,10.,20.,28.,1.3,16.1,26.8,40.2,71.5,3.4,5.7,8.
4520=     C,   16.5,35.5,1.9,23.5,40.,51.8,91.,3.3,5.5,7.5,15.,32.5
4530=     C,   3.4,33.6,53.7,90.3,163.,3.2,5.,6.9,14.,30.,6.7,60.1
4540=     C,   80.,133.4,237.,3.2,4.6,6.3,12.5,26.7
4550=     C/
4560=      DATA D5/
4570=     C    0.,8.8,17.,25.,47.,5.,15.,32.,46.,76.
4580=     C,   2.9,6.8,11.9,14.5,39.,6.,20.5,45.,60.,102.
4590=     C,   2.8,5.7,10.9,14.,38.,8.,29.5,62.,80.5,128.

4600=     C,   2.7,5.3,9.0,13.,35.,15.,46.5,115.,220.,375.
4610=     C,   2.5,5.3,7.,12.,27.
4620=     C/
4630=      DATA D6/
4640=     C    41.1,33.6,32.4,26.7,23.1,20.1,22.2,26.4,29.7,35.7,38.7
4650=     C,   42.3
4660=     C,   38.1,31.8,32.1,27.9,25.0,23.4,25.2,27.6,30.0,34.5,36.0
4670=     C,   38.7
4680=     C,   36.0,30.9,31.8,28.5,27.6,25.5,27.0,28.8,30.0,33.6,34.2
4690=     C,   36.3
4700=     C,   34.2,30.0,31.5,29.1,28.8,27.3,28.5,29.7,30.0,32.4,32.7
4710=     C,   34.5
4720=     C,   32.4,29.1,31.5,29.7,30.3,28.8,30.0,30.3,30.0,31.8,31.5
```

```
      C,    33.0
      C/
       DATA ((D6(I,J),I=1,12),J=6,12)/
      C     31.2,28.2,31.2,30.3,31.2,30.3,31.2,31.2,30.3,31.2,30.3
      C,    31.2
      C,    30.0,27.3,30.9,30.9,32.4,31.8,32.4,32.1,30.6,30.6,29.4
      C,    29.7
      C,    28.5,27.0,30.9,31.5,33.9,33.3,34.2,33.3,30.6,30.0,27.9
      C,    28.2
      C,    27.0,26.1,30.9,32.4,35.4,35.1,36.0,34.2,30.9,29.4,26.7
      C,    26.4
      C,    25.2,24.9,30.9,33.3,37.2,37.5,38.1,35.4,31.2,28.8,24.9
      C,    24.3
      C,    22.2,23.4,30.6,34.5,39.9,40.8,41.

1,37.5,31.8,27.6,22.8
      C,    21.0
      C,    18.2,21.6,30.4,36.0,44.5,45.0,45.1,40.5,32.4,25.8,20.2
      C,    16.5
      C/
       E   N   D
       SUBROUTINE STYPE(JTYPE)
       READ(1,1)ITYPE
    1  FORMAT(A5)
        IF(ITYPE.EQ.5HSAND )GO TO 10
        IF(ITYPE.EQ.5HSANDY)GO TO 20
        IF(ITYPE.EQ.5HSILT )GO TO 30
        IF(ITYPE.EQ.5HLOAMY)GO TO 40
        IF(ITYPE.EQ.5HCLAY )GO TO 50
       JTYPE=-1
       RETURN
```

```
10   JTYPE=1
     RETURN
20   JTYPE=2
     RETURN
30   JTYPE=3
     RETURN
40   JTYPE=4
     RETURN
50   JTYPE=5
     RETURN
     E   N   D
*********************
     SUBROUTINE READD(TMP,PRC,T)
     DIMENSION TMP(12),PRC(12),T(2)
     READ(4,5)T
     IF(EOF(4).NE.0) STOP ' OK '
     READ(4,*) DUM          ReaL (4,2) I4
     DO 10 I=1,12           2 Format (A5)
       READ(4,30) TMP(I)

10   CONTINUE
     DO 20 I=1,12
       READ(4,30) PRC(I)
20   CONTINUE
5    FORMAT(2A10)
30   FORMAT(F6.1)
     RETURN
     END
**********************
     SUBROUTINE ETRN (K,SF)
```

AD-A069 283 ARMY MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT COMM--ETC F/G 8/13
FORECASTING OF THE ELECTROMAGNETIC AND THERMAL PROPERTIES OF SO--ETC(U)
SEP 78 R A FALLS, L MITTELMAN

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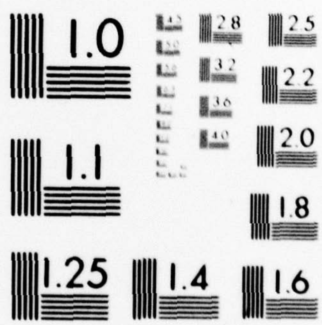

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
      DIMENSION SFD (10,12),SF(12)
      DATA ((SFD(I,J),J=1,12),I=1,10)/13*.55,.56,.57,.58,.59,.60,
     C .60,.59,.58,.57,.56,.55,.59,.6,.64,.66,.7,.72,.72
     C ,.7,.66,.64,.6,.59,.6,.65,.75,.8,.85,.87,.87,.85
     C ,.8,.75,.65,.6,.7,.75,.8,.87,.87,.92,.92,.87,.87
     C ,.8,.75,.7,12*.55,.6,.59,.58,.57,.56,.55,.55,.56
     C ,.57,.58,.59,.6,.72,.7,.66,.64,.6,.59,.59,.6,.64
     C ,.66,.7,.72,.87,.88,.8,.75,.65,.6,.6,.65,.75,.8
     C ,.85,.87,.92,.87,.87,.8,.75,.7,.7,.75,.8,.87,.87
     C ,.92/
      IF (K.LT.1.OR.K.GT.10)RETURN
      DO 1 I=1,12
      SF(I)=SFD(K,I)
    1 CONTINUE
      RETURN
      END
*********************************
      SUBROUTINE INDEX(HEMI,TOTAL,TEVAP,I)
      COMMON/IUN/IU
      H=100.*((TOTAL/TEVAP)-1.0)
      IF(H.LE.-69)GO TO 100
      IF(H.LE.-40)GO TO 150
      IF(H.LE.13)GO TO 200
      IF(H.LE.98)GO TO 350
      IF(H.GT.98)GO TO 400
  100 WRITE(IU,8000)
      I=1
      GO TO 1000
  150 WRITE(IU,8100)
```

```
5600=      I=2
5610=      GO TO 1000
5620= 200  WRITE(IU,8300)
5630=      I=3
5640=      GO TO 1000
5650= 350  WRITE(IU,8500)
5660=      I=4
5670=      GO TO 1000
5680= 400  WRITE(IU,8600)
5690=      I=5
5700=      GO TO 1000
5710= 1000 IF(HEMI.EQ.5HSOUIH)I=I+5
5720=      RETURN
5730= 8000 FORMAT( * AN ARID CLIMATE WITH CREOSOTE BUSH * )
5740= 8100 FORMAT( * A SEMIARID CLIMATE WITH SAGEBRUSH,CREOSOTE * )
5750= 8300 FORMAT( * A SUBHUMID CLIMATE WITH SHORT,TALL GRASSES

5760=     C ,TREES IN CLUMPS IN RIVER VALLEY * )  5770= 8500 FORMAT( * A
HUMID CLIMATE WITH UNDER BRUSH, HICKORY,OAKS
5780=     C ,MAPLE,PINE AND CHESTNUT * )
5790= 8600 FORMAT( * A PREHUMID CLIMATE WITH FIRS,HEMLOCK,
5800=     C AND SPRUCES * )
5810=      END
5820=*********************
5830=      SUBROUTINE THERM(FC)
5840=      DIMENSION AM(12)
5850=      COMMON/MOIS/AM
5860=      COMMON/IUN/IU
5870=      WRITE(IU,5)
5880= 5    FORMAT(1H1)
```

```
      DO 1 I=1,12
        IF(FC.GT.35) GO TO 1
        IF(FC.LE.12) GO TO 6
        IF(FC.LE.18) GO TO 10
        IF(FC.LE.25) GO TO 14
        IF(FC.LE.35) GO TO 18
 6    IF(AM(I).LE.1.0) AM(I)=1.0
      A1=3.446E-4*(7.5*ALOG10(AM(I))+1.0)
        C1=2.0*(0.17+AM(I)/100)
        TD1=A1/C1
        TA1=1/(A1*C1)**0.5
        TP1=(A1*C1)**0.5
      WRITE(IU,7)FC,AM(I),A1,C1,TD1,TA1,TP1            GO TO.1
 10   IF(AM(I).LE.1.0) AM(I)=1.0
        A2=3.446E-4*(14.5*ALOG10(AM(I))+0.9)
        C2=1.9*(0.17+AM(I)/100)
        TD2=A2/C2

        TA2=1/(A2*C2)**0.5
        TP2=(A2*C2)**0.5
      WRITE(IU,7)FC,AM(I),A2,C2,TD2,TA2,TP2              GO TO 1
 14   IF(AM(I).LE.2.4) AM(I)=2.5
        A3=3.446E-4*(6.4*ALOG10(AM(I))-2.3)              C3=1.28*(
0.17+AM(I)/100)
        TD3=A3/C3
        TA3=1/(A3*C3)**0.5
        TP3=(A3*C3)**0.5
        WRITE(IU,7)FC,AM(I),A3,C3,TD3,TA3,TP3
```

```
6180=         GO TO 1
6190= 18    IF(AM(I).LE.2.4) AM(I)=2.5
6200=         A4=3.446E-4*(9.3*ALOG10(AM(I))-3.5)  6210=          C4=1.15*(
0.17+AM(I)/100)
6220=         TD4=A4/C4
6230=         TA4=1/(A4*C4)**.5
6240=       TP4=(A4*C4)**0.5
6250=       WRITE(IU,7)FC,AM(I),A4,C4,TD4,TA4,TP4  6260= 1     CONTINUE
6270= 7     FORMAT(4X,*FC*,F4.1,5X,*MOIST.*,F4.1,5X,*TCOND.*,F6.4,
6280=      C 5X,*TCAP*,F6.4,5X,*TDIFF.*,F9.7,5X,*TR*,F6.2,5X,*TP*,
6290=      C F6.4,//)
6300=       END
6310=**********************
6330=       SUBROUTINE FORM1(I,MODE,LOC,G,E,FRIT,ITEX,TOTAL,TEVAP)
6340=       DIMENSION FRIT(2),LOC(2)

6350=       COMMON/IUN/IU
6360=       IF(I-1)1,1,2
6370= 1     WRITE(IU,3)LOC
6380= 3     FORMAT(1H1,3(/),1X,2A10,2X,'PREDICTION OF SOIL
6390=      C PARAMTERS')
6400=       CALL TEX(ITEX)
6410=       IF(MODE-2)20,10,20
6420= 10    WRITE(IU,11)
6430= 11    FORMAT(1H+,28X,"UNDER VEGETATION",19X,"FC")
6440=       GO TO 6
6450= 20    WRITE(IU,21)
6460= 21    FORMAT(1H+,31X,"BARE SOIL",24X,"FC")
```

```
6    WRITE(IU,30)G,E,FRIT(1),FRIT(2)
30   FORMAT("FC",F6.1,"%",2X,"CRIT.  ",F6.1,"%",
    C 34X,F4.0,"-",F4.0,2(/),"M0NTH MOISTURE"
    C ,6X,7HTHERMAL,1X,5HCOND.,13X,8HSPECIFIC,
    C 1X,4HHEAT,12X,7HTHERMAL,1X,11HDIFFUSIVITY,
    C 11X,7HTHERMAL,1X,8HPROPERTY/,9X,
    C "% BY WT. ",1X,1("MCAL/CM/SEC/*C"),
    C 10X,1("MCAL/CM3/*C"),14X,1("CM2/SEC"))
     RETURN
2    WRITE(IU,40) TOTAL,TEVAP,FRIT(1),FRIT(2)
40   FORMAT(2(/),"+TOTAL RAIN",F5.1,"PAN EVAP.",
    C F5.1,8X,"CRITICAL MOIST.(MM)",F4.0,"

- ,F4.0)
     RETURN
     END
```

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